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ABSTRACT

In 1973, the Education Development Center (EDC) received a grant for the production and support of 65 half-hour television programs. Aimed primarily at eight- to eleven-year-old minority children, the programs were to teach supplementary mathematical topics through real situations, drawing examples from science, technology, and the arts. Hands-on materials were to be used in conjunction with the television shows. This document is a description of a series of meetings referred to as the "Summer Study" that brought together a group to design, develop, and refine plans for EDC's new program in mathematics. The group included psychologists, educators, television producers, script writers, musicians, mathematicians, researchers, and experts in other fields. Components of the summer study described include: project background, summer study organization, internal advisory group, outreach meetings, testing of assumptions, and research and evaluation. (MK)

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A REPORT TO NATIONAL SCIENCE FOUNDATION:

A "SUMMER STUDY" TO HELP PLAN EDC's NEW PROGRAM IN MATHEMATICS

PROJECT ONE

EDUCATION DEVELOPMENT CENTER
55 CHAPEL STREET
NEWTON, MASSACHUSETTS 02160
TELEPHONE: (617) 969-7100

January 31, 1974

SE 029 197

Jerrold Zacharias
Project Director
Project ONE

Leroy Colquitt
Managing Director
Project ONE

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PREFACE

On June 28, 1973, United States Office of Education announced a grant to Education Development Center in the amount of $4,023,027 for the production and support of 65 half-hour television programs. Aimed primarily at minority children ranging in age from eight to eleven, both in classrooms and at home, the television shows will teach a number of topics in mathematics that are supplementary to most ongoing elementary curricula. In general, the program will approach mathematics through the context of real situations, with many examples drawn from science, technology, and the arts. Associated with the television shows will be inexpensive hands-on materials to give children active, highly personal experience with the mathematical concepts and techniques.

Further support for various aspects of the project has come from National Science Foundation, Carnegie Corporation of New York, Alfred P. Sloan Foundation, John and Mary Markle Foundation, and JDR 3rd Fund.

Some of these latter grants were earmarked for special purposes. The NSF grant in particular provided for:

> "... a summer working session which will study the feasibility of a new program in mathematics ... [and which will] gather together a group capable of mapping out the mathematics curriculum content in greater detail, of examining the feasibility of TV production and utilization, and if possible, of generating some prototype materials and programs."

1. INTRODUCTION

This report, submitted to National Science Foundation, describes a series of meetings held at Education Development Center (EDC) during summer and fall, 1973. The meetings formed part of a "summer study"* whose purpose was to help design, develop, and refine plans for EDC's new program in mathematics. Those attending included psychologists, educators, television producers, script writers, musicians, mathematicians, researchers, and experts from other backgrounds. In very general terms, the study was a mechanism for gaining informed advice on a wide range of issues that bear on development of plans for the program. That is, rather than run the risk of "re-inventing the wheel" -- or worse, of needlessly repeating others' mistakes -- we sought out people whose knowledge and experience could help us get started properly.

This report will describe components of the summer study under the following headings:

Project Background: needs, aims, and goals of the project overall

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* Although it is called a "summer study" throughout, and most of the meetings did take place in July and August, these activities continued on into the fall. See Appendix J for details of the fall meetings.

Organization of the Summer Study: a standing core group (or steering committee) working with various groups of experts invited from inside and outside EDC

Internal Advisory Group: persons engaged in other projects at EDC who serve as liaison between this project and others, and who make EDC's accumulated experience available to our newly-formed group

Outreach Meetings: sessions with administrators from some of the school systems where the project is conducting research and plans to run tryouts of shows and materials (Boston, Hartford, Los Angeles County, Oklahoma City)

"Bits and Formats" Sessions: brainstorming meetings with people from a variety of creative disciplines to generate possible ideas for television bits and hands-on activities

Testing of Assumptions: a research activity run in-house during the summer (and later expanded to other cities) to verify our assumptions about the mathematical capabilities of children in the target population

Research and Evaluation: meetings with experts in cognitive development and experimental design to investigate the project's needs and approaches with regard to research, formative evaluation, and large scale testing

Current Issues: three problems that remain important, difficult, and urgent: remedying some of the faults in standardized testing; teacher training on a national scale; and development of inexpensive hands-on materials

In all of these areas, the summer study has produced both important ideas and useful results. We have made substantial progress toward a precise specification of curricular goals; we have developed a large number of preliminary ideas for television bits and manipulable materials; we have come to grips with the problem of attracting and holding the attention and interest of our target population; we have begun negotiations with four cities (and have aroused their enthusiasm and support) with an eye toward involving them in various phases of the project; we have drawn up a preliminary list of criteria for evaluating the program; and we have started necessary research.

Moreover, many of the outside experts who attended the summer study have, as a result, developed strong interests in the project. We have maintained contacts since with a number of these individuals, and doubtless will continue to do so into the future. Relationships of this kind resulting from the summer study have benefited the project considerably. In the long run, this may well represent one of the summer study's most important and durable outcomes.

2. PROJECT BACKGROUND*

Most Americans are very poor at mathematics. At all levels of education, and in all walks of life, there is room for a good deal of improvement in the nation's mathematical abilities.

An international survey has compared the mathematical abilities of students in 12 industrial nations, including the United States.† The results are unmistakable, and should be of great concern to American educators: American children scored below the international average in every age category tested. Moreover, American performance overall was substantially worse than that in every other country tested.

These findings only corroborate what most people already know through their own experience: that mathematics is a painful mystery to a large majority of the population.**

As one approach toward solving this problem, EDC is now undertaking a new educational program in mathematics, involving both television and manipulable materials. Instead of stressing just rote skills, the program will emphasize the

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* Some material in this section is adapted from *Summary, A Program in Mathematics, Drawing Upon Science, Technology, and the Arts, and Using Television and Manipulable Materials*, EDC, pp 1-6.

† Torsten Husen (ed.) *International Study of Achievement in Mathematics*, New York: John Wiley and Sons, 1967. The survey included Australia, Belgium, England, Finland, France, Germany, Israel, Japan, The Netherlands, Scotland, Sweden, and the United States.

** See: Mitchell Lazarus "Mathophobia: Some Personal Speculations," *The National Elementary Principal*, Vol. LIII, #2, January/February, 1974, pp. 16-22.

uses of mathematics in realistic situations, problems, and phenomena, putting mathematics into practical and interesting contexts. In other words, the aim is to teach quantitative thinking rather than just arithmetic.

The program's objectives are somewhat different from those of matnematics education in most schools today. In general, we are less interested in complicated computational abilities, and more concerned with developing a sense of how mathematics can reflect and represent aspects of the world at large.* There can be both satisfaction and utility in understanding that symbols on paper really do say something about reality, or in recognizing mathematical concepts as they appear in real situations. Few children enjoy or talk about mathematics. But most children are intensely curious about the world, and about techniques the "experts" use to understand it. These interests can be used to advantage in the teaching of mathematics.

The target population for this program is minority children -- especially black and Spanish-speaking -- ranging in age from eight to eleven. A program properly directed to minorities should go a long way toward meeting their specific needs, and at the same time is likely to attract and hold the interest of many other children in the target age range. But the reverse is less likely to be true: A program designed for the majority population would probably do little

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*For more detail on the objectives, see *Program Objectives: A Preliminary Version* (attached as Appendix B) or *A Program in Mathematics, Drawing Upon Science, Technology, and the Arts, and Using Television and Manipulable Materials*, Working Draft 3, Section 3, EDC, April 13, 1973. For an elaboration on the rationale, see also: Jerrold R. Zacharias, "The Importance of Quantitative Thinking," *The National Elementary Principal*, Vol.LIII, #2, January/February, 1974; pp 8-13.

to help minority children. By this, however, we do not advocate a "special mathematics" for minority children. Mathematics is universal, and does not recognize bounds of race, creed, color, or language. Still, we do wish to design television shows that minority children will find entertaining and will want to watch. And by doing so, we expect to attract other children as well. Both *Sesame Street* and *The Electric Company* maintain minority identities, but their audiences cut across cultural boundaries.

Quite apart from factors of orientation and identity, the program should be especially suitable for minority children in a number of ways. First, our approach can, to a large extent, uncouple the learning of mathematics from language and reading skills, so that students who have special problems with language should not find this a serious handicap in mathematics. Second, television can bypass many of the adverse social influences that often affect minority children in school. These may include, for example, prejudiced attitudes on the part of some teachers. Also, there are sometimes expectations of poor performance resulting from low test scores, regardless of whether or not the low scores in fact reflect the student's true capabilities. In contrast to some classroom atmospheres, television poses no psychological threat; instead, it can provide a positive-affect, non-punitive environment with which the child can feel accustomed and at ease. Moreover, television makes it possible to embed the

teaching of mathematics in cultural settings familiar to minority students, and to portray both adults and children with whom the audience can readily identify.

Throughout, the program will try to use mathematics in ways that help the child to develop an understanding of both natural and man-made phenomena. It is true that many children -- and most adults, for that matter -- tend to see mathematics as an obstacle to understanding, rather than as a help. By treating the mathematics in context, however, and by showing that it can indeed make some matters simpler, we expect to de-mystify mathematics from an arcane art to a real and useful tool.

3. ORGANIZATION OF THE SUMMER STUDY

Through past experience, EDC has found that one way to begin a program of great complexity and scope is through a concentrated working session that lasts between one and two months, preferably in the summer. This format makes it possible to draw together people from a range of fields and disciplines to collaborate with a minimum of distraction. The summer study atmosphere encourages a kind of immersion and concentration that often leads to significant accomplishment. Moreover, many people who can be helpful in this sort of enterprise are not available at all during the academic year, but are freer to participate during the summer.

One advantage of a concentrated study is that it helps in recruiting people who would otherwise consider themselves too busy doing something else. Moreover, people recruited at first for only the summer study often find themselves so involved in the work that they continue on during the following months. This process -- a person's becoming so captured to a project by his own inventing pieces of it that he would like to continue -- can be very valuable. Indeed, this has been one important result of the summer study reported on here.

A project of this scope needs the assistance of many experts. During the summer study, however, some of

the people whose ideas and advice were most needed could participate for only a few days at a time, as consultants, because of their commitments to other jobs. Thus, it became important to establish a mechanism for maintaining continuity through the meetings.

To this end, we set up a core group -- or steering committee -- as part of the summer study organization. Members of the core group included educators, media experts, experts in the appropriate subject matter areas, and members of the EDC staff who at the time were directing various aspects of the project. The core group also represented the minority constituencies of the project. (There is a list of core group members in Appendix A.)

It was the core group's responsibility to lay out initial concerns for the summer study; to plan sessions and draw up lists of invitees; to charge each meeting with its tasks and goals; to chair the various meetings and make presentations as needed; to assess progress of the summer study from time to time and modify strategies as necessary; and to maintain records and notes for this report. Members of the core group attended all of the summer study sessions, and also met separately on a regular basis.

During the first week of July, the core group convened on its own to discuss and evaluate the program's objectives, including mathematical, heuristic, and affective objectives. These taken together represent the subject matter and philosophy of the project. As such, they influence all of its

policies and components. Moreover, the objectives were to serve as an important point of focus for nearly all the sessions of the summer study.

Copies of the then-current statement of objectives went to all participants in the summer study. (The version in use now, called Program Objectives: A Preliminary Version, is attached as Appendix B.) The document came up for considerable discussion among representatives of the test site cities, the educators and media experts participating in the Bits and Formats sessions, and the psychologists helping to plan research and evaluation strategies. The contributions of each group in turn served to refine, expand, and clarify the objectives, so that the version attached to this report reflects concerns and points of view from a variety of disciplines.

Indeed, the statement of objectives that emerged from the summer study has held up remarkably well. At meetings since with educators, classroom teachers, mathematicians, representatives of other test cities, and individuals in nearly every imaginable field, the objectives have drawn nearly uniform assent and approbation.*

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* The only aspect of the objectives that continues to provoke occasional concern is the lack of stress on elaborate computational algorithms such as long multiplication and long division. School system representatives say that these constitute an important part of their current curricula, and classroom teachers report that such algorithms give many children special difficulty. However, inasmuch as the program presents a supplementary curriculum, we are reluctant to divert precious television time to topics for which television is not likely to be of

The conferences and seminars making up the summer study took place at EDC's facilities in Newton, Massachusetts. Most meetings lasted for three days. In addition to the actual work sessions, some groups toured the production facilities at EDC and took part in a demonstration of television cameras and switching equipment. On display were many examples of manipulable materials, including a wide assortment of "found materials," for participants to experiment with. (These represented some of the kinds of hands-on materials that the program is likely to use.) Most of the groups viewed films EDC has made in conjunction with other projects to sample part of the wide range of possibilities in making educational films. In addition, staff members from other EDC projects met informally with the various groups to explain their projects and to discuss areas of possible collaboration.

Although this phase of the project is referred to as a summer study, some of its conferences and seminars took place later in the year. (See Appendix J for details.) The initial meetings during July and August, in addition to generating considerable information and materials, also helped to clarify issues for later meetings in the fall.

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any special help. Furthermore, most of us involved with the program have come to doubt whether computational skills per se are as important in a child's life today as they were in the pre-computer, pre-calculator, pre-cash register era that saw their introduction into the curriculum decades and centuries ago. For a more complete discussion of this point, see *A Program in Mathematics, Drawing Upon Science, Technology, and the Arts, and Using Television and Manipulable Materials*, (Working Draft 3), Section 3, EDC, April 13, 1973.

4. INTERNAL ADVISORY GROUP

While the summer study was in its planning stages, it became clear that the resources already available at EDC -- in particular, a number of very experienced and knowledgeable educators and curriculum developers -- could be a valuable asset to the project. This led to the establishment of an Internal Advisory Group made up of persons presently engaged in other projects run by or coordinated through EDC. The function of the Internal Advisory Group is to provide a permanent, ongoing liaison between the new mathematics project and the collective experience and expertise at EDC. Furthermore, members of the Group as individuals are qualified to offer advice and assistance based on their own experiences in setting up and implementing new educational programs.

During the summer study, the Internal Advisory Group met for the first time. After members of the core group made brief presentations to explain the goals, scope, and problems of the project, the Internal Advisory Group spent some time discussing ways in which it could help the project.

For example, EDC already has programs operating in many American cities and in several countries overseas, and so has developed good working relationships with educators and school system administrations in a wide range of locales -- some of which will be appropriate sites for testing the new

program. Thus, through the Internal Advisory Group, it will be possible for the project to tap into an existing network of persons and agencies committed to improvements in education and already familiar with EDC and its work. The advantages of such an arrangement have surfaced already: One member of the Internal Advisory Group, working with an EDC project in Atlanta, facilitated negotiations with Atlanta that have since resulted in our carrying out preliminary research there. Atlanta will most likely be a continuing test site for the program.

Another member of the Internal Advisory Group, with experience in many areas of publishing, has assisted us in preparing and distributing press releases and in otherwise publicizing the project.

The Internal Advisory Group has no specific detailed charge at present. Its role will doubtless clarify as the project proceeds, and as members of the Group stay abreast of the program and its developments. (Most members work in the same building that houses the new project, and some meet frequently with project staff members either socially or on other EDC business; accordingly, they are in an excellent position to stay informed about the project between official meetings.) Our main request to Internal Advisory Group members for the time being is to act as an "early warning system," monitoring our progress to sound an alarm if the project begins heading off in inappropriate directions. The Group's association with the project and its staff, combined with a lack of direct, day-to-day involvement, may enable its members

to detect some of the possible problem areas more quickly than those of us who are more closely engaged.

We expect that the Internal Advisory Group will also be helpful in suggesting, locating, and perhaps recruiting potential new consultants and staff members.

A list of the Internal Advisory Group members is attached as Appendix C.

5. OUTREACH MEETINGS

Representatives from four school systems (Boston, Hartford, Los Angeles County and Oklahoma City) attended the summer study to discuss the possible involvement of their respective cities in the program, particularly during the test phases. Furthermore, the group was extremely helpful in conveying to the project staff the kinds of influences and concerns that will affect program adoption in any major American city. Having seen at first hand the introduction of many innovative programs in the past, these men and women were prepared to alert us to some of the possible obstacles and to suggest strategies for overcoming them.

Before the summer study began, while negotiating with cities as possible test sites, EDC was fortunate to secure the enthusiastic participation of both Los Angeles County and Oklahoma City. Negotiations with Hartford and Boston began during the summer study itself, and have since been completed successfully. More recently, Atlanta has joined the list of test cities, and negotiations with New York City are now underway.

The selection of appropriate test sites is important. Not only should their populations represent the national target population, but individuals and organizations in the test cities must be willing to cooperate wholeheartedly and

enthusiastically. Information derived from the pilot studies, apart from being accurate and complete, must feed back to the project staff quickly and smoothly. Since errors or delays in evaluation data could lead the project into serious difficulty, real commitment on the part of test cities is essential.

In searching for appropriate sites, the project staff had in mind a number of criteria which the summer study outreach meetings refined and expanded upon:

-- sufficient minority representation in the student population, especially as regards black and Spanish-speaking students

-- access to local television broadcasting facilities

-- television sets in a sufficient number of classrooms

-- access to classrooms for the project staff

-- some degree of choice by project staff over which classrooms take part in evaluation studies

-- voluntary cooperation of teachers (and of teachers' unions, where appropriate)

-- a pool of available paraprofessionals (or interested parents) to assist in the evaluation process

-- commitment of the school system administration

-- acceptance of the program by parents

-- receptivity of the community in general to education reform

From the standpoint of size alone, Los Angeles County should be an ideal site for testing the program: The County's 95 school districts educate some 1.7 million children, making it relatively easy to choose appropriate samples for pilot studies. Furthermore, the Los Angeles student population includes many Spanish-speaking children and a substantial number of non-reservation Native Americans, as well as a large representation of Blacks.

Dr. Henry Palmer and Mr. Robert Gerletti, who represented Los Angeles at the summer study, expressed their school system's enthusiasm in joining with the project as a test site. They reported that all classrooms in Los Angeles have television sets and that color sets have been ordered; therefore, equipment should be no problem. There are three UHF television stations that the project could approach for airing shows. And since many teachers are already using manipulable materials in their classrooms, there should be no special resistance to the introduction of hands-on materials as part of the project. Furthermore, the general educational atmosphere in Los Angeles County should be highly conducive to the introduction of this new program.

Oklahoma City also offers a number of advantages as a test site. It has some of the characteristics of a southern city, but also represents mid-America in many respects. It has a substantial black population, and we hope to reach as well some of the Native American children on reservations nearby.

Associate Superintendent Mervel Lunn, Ms. Martha Dodson, and Ms. Mary Frates attended the summer study on behalf of Oklahoma City. They reported that their school system has its own UHF channel with a signal stronger than the local VHF station, and that every classroom has a television set. Neither the project's access to airtime nor children's access to receivers should present any difficulty.

Perhaps the greatest contribution that both Los Angeles and Oklahoma City can make as test sites is their emphatic willingness to participate in developing techniques for research and evaluation. In addition to helping with the design of instruments, the two school systems have agreed to field test the instruments. Both school systems have their own evaluation departments which can assist EDC in its assessment of project materials. This support and cooperation at the local level should contribute greatly to the overall success of the project.

Prior to the summer study, the EDC project staff had not anticipated such strong commitments from these two school systems. We are gratified and encouraged by their endorsement of our goals and methods, and by their indication of faith in our eventual success.

The additions of Boston and Hartford as test sites will improve the geographic spread, necessary for trustworthy research data. Hartford has expanded its Follow Through program this year to include grades three through eight, which overlaps the target age group for our program. The project should tie

in well with the learning opportunities offered as part of Follow Through.

Ms. Gertrude Abery and Ms. Ann Michaelis of the Hartford school system attended the summer study. Our conversations with them at that time led to further negotiations with Hartford, and have since resulted in the inclusion of Hartford as a test site for the program.

During the various stages of project development, it will be important to have a test site close enough to EDC that we can try ideas out quickly, obtaining immediate feedback. For example, staff members themselves should be able to visit classrooms occasionally with videotapes and prototype hands-on materials without needing to wait for design of a formal evaluation apparatus. Boston -- represented at the summer study by Mr. John Young -- will be an ideal city for this purpose. Its multi-ethnic student population, and its range of characteristics similar to those of many other large American cities, make it a suitable testing base.

The negotiations with Boston that began during the summer study are now nearing completion with the recent formal approval of the Boston School Committee. A few details remain to be worked out, but there is no doubt that Boston will participate in the program as a test site.

Hartford and Boston each have access to two educational television channels, and have television sets available in classrooms.

Although not involved in the summer study, Atlanta has since joined the group of project test sites. Like the other cities mentioned, Atlanta has an educational television channel available and has television sets in classrooms. Moreover, it is a southern city that other cities in the South tend to look to for innovations. In recent years, Atlanta has undertaken a number of significant educational programs, at least one in collaboration with EDC.

EDC has already taken concrete steps with all of the cities discussed above -- Los Angeles County, Oklahoma City, Hartford, Boston, and Atlanta -- to establish their participation. A preliminary research study, designed to ascertain existing mathematical skills in the target population generally, has run in all five cities. (The study is treated in more detail below, under the heading Testing of Assumptions.) The numbers of children who participated in each city are:

Los Angeles County	150
Oklahoma City	90
Hartford	90
Boston	90
Atlanta	70

Apart from providing data that will be very helpful in designing the initial television shows, the study served to initiate contact with many administrators, teachers, and children, and to cement our relationships with the test site cities.

The involvement of these cities is only one part of the project Outreach component. Under the Outreach Director, Dr. Irvin Vance, the project staff will work with each city

to develop community and teacher involvement with the project. There will be a local advisory group in each test city with whom the Outreach staff will work closely.

Meeting participants agreed that in-service teacher training will be a critical factor in the project's success. Although teacher involvement will be a major undertaking of the Outreach component in cooperation with participating cities, the details did not come up for much discussion at the summer study Outreach meetings. The group seemed to take it more or less for granted that our staff must provide for adequate teacher training on a very large scale if the program is to operate effectively in classrooms. (This topic is treated more completely under the heading Current Issues.)

School system representatives expressed concern about a possible negative reception to the project by parents and teachers who might see it as just one more "new" educational program that could cause confusion among children. To the apparent satisfaction of the participants, the staff explained that the program is not designed to replace existing mathematical instruction in the classroom, nor is it just one more "new" method of teaching mathematics that will outdate previous mathematical instruction. Rather, the program is designed to complement and expand existing mathematical instruction. Those attending stressed the importance of making this known to schools and communities considering adoption of the program.

In order to help accommodate these concerns, the Outreach staff now plans to review existing mathematics curricula in the test cities so as to point out to parents and teachers those concepts and skills that overlap with current practice in the schools, along with those that are new with this program.

Representatives also pointed out that the mathematical content of current large scale standardized tests differs from that of the new program, and cautioned against endorsing any evaluation of the program based on such tests. There will be, they said, a strong tendency on the part of some school administrations to assess the effects of the program largely on the basis of test scores, and so the project must be ready to offer a workable alternative to existing tests. One approach toward solving this problem would be the development of new tests that reflect the program's content and philosophy, and which treat minority students more fairly than current tests do. For a discussion of this point, see the section called Current Issues.

As one result of the summer study, it became clear that the Outreach component will bear the major responsibility of maintaining a steady communication flow between the staff at EDC and the program users in the test cities. The Outreach component will be coordinated through EDC in Newton, but as much of the operation as possible will be handled through local task forces in each city. (Again, see the section on teacher involvement under Current Issues.)

6. "BITS AND FORMATS" SESSIONS

The Bits and Formats meetings had two purposes: first, to present the mathematical objectives planned for the program to the visiting group and to discuss their appropriateness and relevance; and second, to initiate a flow of ideas for the television shows. Beginning with the assumption of a magazine format, we anticipated that television ideas might come in three forms: (1) "bits" -- one-time segments running anywhere from a few seconds to a few minutes; (2) "small formats" -- situations and/or characters that might form the common basis for a number of different bits recurring from show to show; and (3) "large formats" -- show-long structures that might remain the same from each show to the next.

Those attending the sessions -- two three-day meetings, held one week apart -- included television producers, script writers, musicians, filmmakers, authors of books for children, mathematicians, playwrights, and educators. Appendix D is a list of participants.

During the initial discussions, there was a general consensus on several points. The programs should:

-- present mathematics in entertaining ways
-- portray examples and illustrations in contexts that will appeal to minority children

-- de-emphasize the traditional concept of right and wrong answers
-- repeat key mathematical concepts in a variety of different situations
-- encourage children to look at mathematical problems from many different perspectives
-- be designed so that children need not see shows in sequence, and need not see every one
-- appeal to teachers and parents as well as to children

A few of these items may require some elaboration. There is a very strong possibility that each child will miss some shows, especially if viewing at home. Accordingly, it will not be practical and effective to sequence the segments and programs as arithmetic books and programmed mathematics instruction traditionally do. Instead, the full series of shows should provide a child who sees any two-thirds of the material with exposure to essentially all of the subject matter. For example, repeating key concepts in various contexts would let children miss some shows without boring children who watch all of them. And this kind of repetition would also give children who did not fully understand the first explanation a chance to look at the same concept explained in other ways.*

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*It is not always necessary to teach mathematics in the fixed, rigid sequence of topics used in most elementary curricula, even though most people now learn mathematics that way. Otherwise, it would be much more difficult to design the television shows effectively. For a discussion of this point, see *A Program in Mathematics, Drawing Upon Science, Technology, and the Arts, and Using Television and Manipulable Materials*, (Working Draft 3), Section 2, EDC, April 13, 1973.

The group hoped that the television programs would reach and appeal to a secondary audience: those adults and older children who might benefit from material having to do with mathematics in ways that stimulate imagination and curiosity. Since the programs may be aired not only during school hours but also later in the afternoon, when children can watch at home, it may be possible to influence the mathematical skills of an audience much larger than the specified target population. Also, if many parents take an active interest in the shows and their mathematical content, this may help and encourage some children.

During the first three-day meeting of the Bits and Formats group, participants devoted much of their discussion to the need for providing adequate minority viewpoint and participation in a program designed for minority children.

Almost all of the materials now in elementary schools are meant primarily for white, middle-class children, in that they portray mostly middle-class characters and situations. There have been some attempts to improve this situation in recent years, but the participants at this session -- especially the minority participants -- felt strongly that minority cultures, viewpoints, and backgrounds are still badly underrepresented in classroom materials. Their expressed concern went beyond whether the books show children with black features and Spanish names; rather, they spoke to the absence of classroom materials that engage a typical minority child in terms of his own life experiences. Suburban situations, for example, are alien to

most children living in the inner city, even if the suburban child is portrayed as black. Authors of elementary textbooks and other materials seldom recognize the reality of the minority child.

Many participants felt that this is due largely to the fact that most textbook authors, and others who produce curricular materials, are themselves white and middle-class, with backgrounds sufficiently different from minority children that their intuitions are simply not equipped to produce materials that meet minority children's needs.

There is a parallel situation in television production. Nearly everyone engaged in the creative aspects of television -- producing, writing, and directing -- is white. This may account for the white frame of reference that pervades nearly all of television. And even when minority persons appear on television, it is most often in terms of white stereotypes and from a middle-class point of view.

The meeting quickly came to a consensus that this orientation will not do for the program we are planning. Instead, it will be necessary to reach minority children on an emotional level, in terms that relate to the world as they perceive it. This may mean, in effect, accepting as legitimate many of those aspects of a minority child's life that are not now part of the American mainstream, and portraying these on the screen faithfully enough that every child will feel that at least part of every show speaks directly to him or her.

Beyond this point of agreement, however, participants differed on the staff and organizational structure that would be most effective in producing such a program, with its combined elements of the need to attract and hold a minority audience, and a curriculum and pedagogy that many adults find unfamiliar. Moreover, some participants felt strongly that the mathematical objectives already proposed for the program are not particularly appropriate for minority children, and that the program should instead concentrate on the computational skills stressed currently in elementary mathematics education. In sum, the discussion centered around the question of who -- what kinds of people -- would be making important decisions for the program.

Expressed opinions ranged the spectrum from "minority representation," through "minority input" and "minority participation," to "minority control." That minority people must work in every aspect of planning and production was never in dispute. Rather, some participants were seeking a clear statement as to who would have the final say on certain important issues (such as mathematical objectives, program design, scripts, choice of production subcontractors, and hiring and firing), while the project staff did not feel ready at that time to make such a statement. Occasionally the debate grew quite heated.

Another issue that concerned many participants stemmed from the fact that some of the project's upper-level management personnel are white. Would these people be sensitive to minority needs and concerns? What mechanism would ensure them adequate input on minority points of view?

The minority participants eventually decided to meet for one morning as a separate group to discuss their position among themselves. The outcome of this caucus was a set of recommendations directed to the project staff (and attached as Appendix E) concerning the project's minority orientation. Since the summer study, the project staff has worked to implement as many of the recommendations as it could, allowing for the many constraints that affect a project of this size and scope. The Project Director's response to the minority recommendations is in Appendix F.

Not all of the Bits and Formats meetings, however, were taken up with these discussions. During part of the first three-day meeting and all of the second, participants, working in small groups, suggested a large number of discrete segments and bits which can be incorporated into programs once a general format is established. And there were also a few proposals for overall formats. As individuals presented various ideas, others in the groups tried to convert and adapt them to different cultural contexts so that the universality of many of the concepts eventually emerged. The groups also probed script ideas to see if they were as applicable to the rural child as to the urban child. In creating characters and working out ideas, participants attempted to eliminate the traditional male/female, racial, and cultural stereotypes. A compilation of the ideas discussed during these sessions -- some of which will likely appear in the television shows -- accompanies this report as Appendix G.

7. TESTING OF ASSUMPTIONS

Before the summer study began, the project staff started the task of drafting a preliminary set of mathematical objectives for the program. In the course of doing so, it became necessary to make some specific assumptions about the mathematics that children in the target population might know before their exposure to the program, since it proved very difficult to fix appropriate desired outcomes without at least a rough notion of the children's prior capabilities. Accordingly, the group developing objectives (which included some teachers involved daily with target population children) worked out a set of assumptions about the children's mathematical concepts and skills under each of the five mathematical areas that form the program's objectives. These appear in Appendix B.

As this development of objectives proceeded, the staff realized that the underlying assumptions should be validated for the target population by actual experiment. Accordingly, 90 children from the Boston area came to EDC during the summer to take part in an empirical study under the direction of Ms. Joyce Baynes. (This overlapped in part with the summer study, and so afforded some summer study participants an opportunity to observe at close range minority children at work in a learning environment.) The staff paid children for their time, and made it a point to inform them about the purpose of the study, so that they would be participants in the

research and not just passive test subjects. Although the children did not constitute a statistically random sample, they were more or less typical of children in the target population.

The basic design had each child working with the staff for a total of eight hours spread over several days. The children were divided into groups of five, each group working with one teacher and being observed by another staff member.

The experiment took the form of several games designed specifically to examine the assumptions in Appendix B. By watching the children play and by examining their record sheets afterwards, observers could draw conclusions about whether or not the assumptions were correct for these particular children. It was possible to assess the children's mathematical knowledge, the processes they used to solve mathematical problems in some cases, and how they approached new problems. The purpose of this study was not to teach the children anything new, but rather to find out how much they knew already. The relaxed, non-threatening atmosphere encouraged them to perform to the best of their ability. Indeed, the children enjoyed the sessions immensely; most were sorry to see the experiment end.

Following each session, the observer and teacher supervising the group compared notes so as to have as accurate an assessment of each child as possible. The staff teams wrote complete reports on the children's experiences.

We also needed information about children's television viewing preferences. Although there have been some previous

studies of children in the target age group, we have not been able to find data that relate specifically to minority children. To help fill this gap, the staff individually interviewed each child in the study about his or her television habits. The interviews were oral (rather than written questionnaires) to ensure that the children would understand the questions and adequately explain their views. The interviews, conducted during two 30 minute sessions, also allowed the staff to determine which questions elicited the most useful responses, and to encourage the children to elaborate on their answers. The children seemed to enjoy the attention, and most were pleased that an adult would solicit their opinions and take notes on the answers.

A number of summer study participants raised the question of whether the sample of Boston children taking part in this experiment in fact represents the national target population. Discussions on this point eventually led to replications of the study in four other cites: Los Angeles County, Oklahoma City, Hartford, and Atlanta for a national total of 490 children. Overall, this pre-pilot research has supplied data that will be indispensable to planning the program. Doubtless, however, it will be necessary to revise our assumptions somewhat on the basis of classroom experience with the first several television shows.

A more complete report on the study, its replications, and its findings is attached as Appendix H.

8. RESEARCH AND EVALUATION MEETINGS

Plans for the project concerning research and evaluation encompass a number of distinct activities designed to build upon and supplement one another in a systematic way:

1. Testing of assumptions concerning the target population's mathematical abilities, described above and in Appendix H;
2. A "feasibility study," funded by Carnegie Corporation, to explore the compatibility of television and hands-on materials and to try different ways of preparing teachers to use the program, this involving the production of one hour of videotape and associated hands-on materials, with classroom testing in six cities;
3. Production and classroom testing of isolated television bits to investigate different styles and modes of television teaching (formative evaluation);
4. Production and classroom testing of 13 experimental half-hour shows to explore different television formats and ways of organizing and integrating entire shows (formative evaluation);

5. Production and classroom testing of the first 26 half-hour shows for national broadcast and associated hands-on materials (formative evaluation);

6. Production and classroom testing of the final 39 shows and their hands-on materials;

7. Summative evaluation of the entire program (not yet funded).

All of these activities will take place in the project's six test site cities, and will require the cooperation of school administrations, teachers, parents, and students. The early stages should help to clarify philosophy, objectives, and broad approaches to pedagogy; later stages will provide more specific information about particular television segments and hands-on activities. The entire process should help us to evaluate different modes of teacher preparation.

Along with these evaluation studies, two other research activities will be necessary to the program's success. One is a study of cognitive processes in children as these relate to the learning of mathematics; surprisingly, comparatively little is known about how children acquire mathematical concepts and skills. The other is the development of new large-scale tests to examine mathematical achievement, since the tests currently in use show severe deficiencies with respect to this

program. (Recall that participants at the Outreach Meetings felt strongly that existing tests are inappropriate to the program, and could do it considerable harm.) Neither of these activities is funded at present.

In order to begin the extensive research and evaluation task, EDC invited a group of psychologists to the summer study. This aspect of the project is especially demanding because it involves the design of instruments of many different kinds to determine the competencies of children in areas that are presently "soft ground" in psychology, as well as an attempt to influence the entire field of educational testing.

The research and evaluation group was very concerned with the tyranny of educational testing in general and the inadequacy of mathematical achievement testing in particular. The group spoke of arriving at an entirely new method to assess mathematical learning in children: a method that would not cause children anxiety under testing conditions, that would determine how much they know rather than how much they can remember, and that would assess each child as an individual rather than as a percentile score. Further, the group hopes to convince publishers of current standardized tests to cooperate in this venture, since a new testing mechanism will not help children at all if school systems continue to use traditional tests (such as the Metropolitan Achievement Test) as the ultimate yardstick. Neither this program nor any other innovative mathematics

program can do much if children's competence will always be evaluated by traditional methods, and in terms of traditional objectives.

There are two distinct issues here: The project staff will need instruments and techniques for formative evaluation, and school systems will need instruments to gauge their students. In all probability, these two needs will best be served by different types of instruments, although the formative evaluation process may turn out to be a useful proving ground for large scale tests.

The discussion called into question some of the rules that govern traditional testing. For example, the major criterion for a traditional test is that it be objective; as a result, nearly all traditional tests are in multiple choice format and scorable by machine. But a method of testing dictates the content of the test to some extent. A multiple choice test makes it impossible to assess the method by which a student arrives at an answer, to assess creative problem solving, or to assess how a student makes use of available manipulable materials in a mathematical context. Also, it may be that computational skills dominate existing tests as they do partly because they lend themselves so readily to the multiple choice format -- and not necessarily because they have to be that important in curriculum. (Of course, once a skill plays a large part in the tests, it is inevitable that school systems will begin taking this into account when planning curricula.)

The difficulties with current tests and the project's plans for developing new tests are discussed more completely under the heading Current Issues below.

On the subject of formative evaluation, participants cautioned us against adopting a rigidly controlled design of the type often used by laboratory scientists, even though such designs have been very popular with education researchers in the past. When dealing with human beings, one can never isolate all of the relevant variables. And in examining the effects of a television program available on open broadcast, it will be very difficult to maintain a control group that receives no exposure at all to the shows.

Among the possible designs for studying mathematical learning in children due to the program, one suggested approach is to videotape children watching some of the television shows. This would let us observe how they interact with one another and hear what they talk about during and after exposure. If there are manipulable materials in the room, do the children use them? How creative are they in using them? One could place hands-on materials in a room with two groups of children -- some who have seen the television shows and some who have not -- to see if there are any appreciable differences in ways that the groups approach the materials. A similar observational technique is used by Dr. Herbert Ginsberg of Cornell University and his associates; along with Dr. Ezra Heitowit, he and a group of graduate students demonstrated the procedures to the project staff at a follow-up meeting in September.

In a more general discussion, the research and evaluation group suggested the following criteria as potentially useful guidelines in setting up evaluation procedures for the project:

1. Do children in the target population like the program? Along with survey data and reports from teachers, it may be useful to interview and videotape children, for we shall need to learn not only whether children like the shows, but also why they like or dislike particular portions.

2. Do the children show competence in the mathematical skills and concepts that the program tries to teach? Clinical observations, together with written tests and "game" instruments (such as those used in the testing of assumptions) should help to answer this question.

3. Do children approach problem solving in original ways? Again, clinical observation and interviews would contribute data on this point.

4. In general, do the children do better in school? There are two components to this question: improvement in mathematics achievement in particular, and improvement in school performance overall. An answer to the first depends to a large extent on just how the schools choose to

measure competence in mathematics. A child could have a much stronger command of useful mathematics, but still not do appreciably better on existing tests; hence, it will be an indispensable part of the evaluation process to offer alternative tests. With regard to school generally, it may be that improvements in quantitative skills can have ripple effects that carry over to other school subjects. A higher self-esteem, for example, arising from mastery of mathematics -- a subject that many people consider difficult -- might help break down the sense of inevitable failure that some children carry. And a better grasp of mathematical skills could give the child more confidence in dealing with the adult world.

5. Is there widespread acceptance of the program by children, parents, and school systems?

6. Does the program improve the lives of children? This is, of course, the hardest question to answer, but is very important over the long term. One would first have to consider what an improved life means. For example, one possibility would be to see if children who participate in the program show an interest in professions that require mathematical backgrounds.

> Another possibility is to observe how children use mathematics in their everyday lives. Does their vocabulary change? Are they interested in different things? Are they interested in the same things for different reasons? Do they know when and how to use mathematics as a tool? In general, it would be very desirable (but extremely difficult) to ascertain whether the program has appreciable effects beyond the immediate confines of the classroom.

Although the problems of evaluation are still far from solution, the group was optimistic about creating designs that not only will be of value to this project, but which also can have an impact on the rest of education.

As one result of the research and evaluation meetings, the project has successfully engaged the interest of a number of highly qualified and competent people. They have all expressed enthusiastic support of the project, and have indicated their wishes for continued involvement. One participant, Dalton Jones, has since been of great help to the project through his regular and continuing work as a consultant; other participants have remained in close touch.

A list of those who took part in the research and evaluation meetings is attached as Appendix I.

9. CURRENT ISSUES

As with many successful inquiries, the summer study raised more questions than it answered. Including the fall sessions (see Appendix J), meetings generally tended more toward defining problems than arriving at final solutions. While this is certainly a necessary step in the evolution of a complex project, it does mean that some of our issues are still far from settled and some of our detailed plans and procedures far from being clear.

In a number of areas, nevertheless, we have made very satisfactory progress. The program objectives are now well in hand; a preliminary research study about the target population's mathematical capabilities is complete; several test cities perfectly suited to our needs have joined the project; we have begun a collection of possible television segments; broad plans for formative evaluation have taken shape; and -- most important -- we have been successful in attracting qualified and capable men and women and in assembling a first-rate staff.

On the other hand, some aspects of our planning are still conspicuously soft. Some of these problems do not worry us; for example, even though we have not yet arrived at definite formats for the television shows, we have no

doubts about these decisions falling into place at the proper time. But there are certain other unresolved issues causing us more concern. These share three characteristics: first, they must yield to practical solution if the project is to succeed completely; second, we have not yet had the opportunity to test our tactics for solving them; but third, we are confident that our analysis of the problems and our general approaches toward solutions are feasible and correct; and indeed, we know how to begin in each case.

The first issue is one that arose often in summer study discussions: the matter of large scale testing. Both school system representatives and visiting psychologists, speaking in very strong terms, cautioned us that failure to provide alternative tests could jeopardize the entire program. The faults in existing tests -- quite apart from their content, which is inappropriate to our needs -- almost certainly will give test results that misrepresent the program's effects. There is more on this below.

The second problem arises from the proposition that in order to reach a great many children we must also reach many teachers. There are approximately 500,000 teachers in the United States working in Grades 3 through 6. To reach any appreciable fraction of these men and women with an adequate involvement program will be a

task of immense proportions. Nevertheless, our mathematical objectives and pedagogical approach are uncommon enough that an absence of adequate preparation might risk some teachers neutralizing the program's benefits -- a point with which summer study participants agreed. We shall need teachers' active, wholehearted cooperation and their initiative in the classroom. Hence, we must give teachers background in the objectives and confidence in the approach.

The third unresolved task involves the design of hands-on materials to which all students can have access. At the summer study, school system representatives doubted whether less affluent systems would be able to make substantial contributions toward the purchase of materials. The alternative must be to design materials that cost little or nothing. EDC has already put together one such program -- the African Primary Science Program, very well received abroad -- but the problem of devising materials for American children, whose tastes are more sophisticated, is likely to be more difficult. Indeed, one important thrust of the television shows will probably be to inform children about the resources available in typical communities, and to encourage them to see the community (including homes and schools) as a potentially rich source of things and activities. Ideally, by learning the skills and self-confidence that enable a person to acquire information and materials on his/her own, children themselves

should be able to locate most of what they need for their work. But not all children and school systems will be inclined to the find-it-yourself approach, and so we shall provide other, more formal options as well.

The sections below examine these three problems -- large scale testing, teacher involvement, and inexpensive materials -- in greater detail.

Large-Scale Testing

Several properties of the large scale tests in current use (oi which the Metropolitan Achievement Test, Sequential Test of Educational Progress, and California Achievment Test are examples) make them unsuitable to our needs.

Perhaps the most prominent characteristic is the particular mathematical abilities that they test for. On the average, about 70% of the items in existing tests require the use of computation -- addition, subtraction, multiplication, division, manipulation of fractions -- for arriving at the correct answer. In other words, a child who is deficient in computation is certain to do badly on these tests, regardless of his/her grasp of other mathematical concepts and techniques. Our program will not stress computation as much as do most current curricula, and so tests with a great deal of weight on computation cannot assess the program properly.

Thus, one of our tasks is the development of new tests, suitable for administration to many thousands of children, that reflect the program's mathematical emphases.

While we shall have to confine ourselves to the machine-scorable multiple-choice format, at least at the outset, we hope to avoid some of the difficulties that multiple-choice has given rise to in the past.

1. Current tests put a very heavy premium on reading and on other linguistic skills. Before a test is a mathematics test, it is a reading test first. But many children have special difficulty with reading -- including both black and white children who are not taught to read the variations of standard English that they speak at home and in the streets, and Spanish-speaking children who ordinarily use a different language entirely. The tests inadvertantly penalize a child for his/her lack of skill in reading a particular language by assigning a poor score in mathematics -- an obviously unfair practice. For Example, children in Grades 4 through 6 taking one widely used test must read the following directions:

   "You will make your best score by answering every question because your score is the number of correct answers you mark. Therefore, you should work carefully but not spend too much time on any one question. If a question seems to be too difficult, make the most careful guess you can, rather than waste time puzzling over it."

We hope to reduce the reading factor somewhat by using pictorial questions liberally. And we shall certainly provide simpler instructions.

2. To make matters easier for the scoring machine, children must now mark their answers on a separate sheet or card printed with rows and columns of little spaces. The student indicates his/her answer by shading in the space beside the question number being answered and above the letter corresponding to the answer chosen. (At least one test has two extra columns, NG for "not given" and DK for "don't know".) While simple in theory, this answering procedure demands considerable orderliness and attention to detail -- traits that some children lack. Whether or not these traits are worthwhile in their own right, it is not fair to require them for a good score in mathematics. One alternative would be to print questions in the test booklet in blue and simply ask the student to cross off in black the answers he/she considers wrong. After a machine has sliced off the binding to produce a sheaf of loose papers, the entire question booklet goes to the computer for scoring.

5. Current scoring practice pools all of the test items into one, two, or at most three scores, making results nearly useless for diagnosis. A teacher who knows that a particular student is doing badly in mathematics still has no information from these tests about how to assist him/her. Instead, however, it should be feasible to report a profile on each child (and another on the entire class) that shows relative ability in each of several categories. This could greatly aid the teacher in using classroom time to best advantage -- by conveying, for example, that the class is having trouble with long division because many students do not yet fully understand multiplication. In order to arrive at such a profile, it may be necessary to derive the reported scores in each diagnostic category by examining interactions among a number of individual item responses. (This is never done in current practice so far as we know; rather, the reported score now is just the total number of items answered correctly, corrected for guessing, weighted, and scaled to a percentile or grade level.)

4. In order to be useful, a test must be "valid" -- that is, it must test what it is supposed to test. Nowadays, however, achievement tests are "validated" mostly by comparison against other, respected tests, with little attempt, if any, to confirm validity more scientifically by checking against a number of independent criteria. Instead, a new test might be considered valid if it correlates well with, say, the Metropolitan Achievement Test. This practice leaves us uneasy because of our limited confidence in the existing tests. Hence, we hope to validate our new tests more directly and through several different methods at once. One approach, employing games of the type we used to examine prior mathematical abilities in the target population (Appendix H), would look for correlations between responses on particular kinds of items and performance in particular kinds of games. Another standard against which to assess the validity of test scores might be the child's activities with hands-on materials. A third possibility would implement tests on an educational computer, such as PLATO at University of Illinois -- a medium that would let us introduce modifications to the test quickly and easily, and that could provide very detailed running records on each child's performance. One overall

approach is to develop tests on PLATO at first, correlating results as we go with diagnostic games and hands-on activities. For efficiency in validating individual items, the computer could branch automatically while administering the test, choosing next questions on the basis of answers already given. If the programmers are thoughtful, this could help to determine whether individual item responses do in fact represent the child's capabilities. For example, a wrong answer might lead to a series of questions that probe just why the child chose the particular answer that he/she did, while a right answer could produce a few more questions of the same general type to ensure that the child's response was not wholly fortuitous. PLATO would enable us to carry this operation through with a large number of children at moderate cost. Then, once a test is ready, it could easily be printed out and made ready for wide distribution. Looking at validation from a scientific point of view, we feel that no single basis can ever be sufficient. Rather, we should assess the validity of items and tests in as many different ways as possible, even though this may eventually entail a considerable amount of work on our part.

5. An atmosphere of military secrecy surrounds much of educational testing today. Parents, for example, very seldom have access to the tests that play such a large part in decisions governing their children's educational careers. In general, secrecy tends to hinder open discussion about issues that relate to testing. (One sees a book like Christopher Jencks' Inequality in a very different light after looking over the tests on which he bases his conclusions.) To circumvent this atmosphere, we plan to publish a manual containing a very large number of typical test items for distribution to teachers, parents, and children. This would include several items of each type that appear on the tests, including perhaps some of the same items making up the actual tests, along with clear discussions of the rationales for each kind of item and a detailed explanation of scoring procedures. This would help to bring the whole matter of testing into the open.

In short, we see much of current educational testing as counterproductive, and even destructive. The limitations inherent in the tests themselves should caution anyone against taking their results too seriously. Yet

educational systems make critical, long-term decisions about children's futures on the basis of these scores. We hope to offer the beginnings of an alternative in the field of mathematics testing.

Teacher Involvement

We plan to organize our teacher involvement program around an "Outreach Center" in each city using the program, beginning with the six test site cities: Atlanta, Boston, Hartford, Los Angeles County, New York City and Oklahoma City. Staffed with local personnel and in frequent touch with an assigned advisor belonging to the project staff, the Center will in effect be a "branch office" of the project, equipped to handle all of the problems and questions likely to arise as the program gains momentum in a particular city. The Centers will serve as the main points of coordination for teacher training, will be distribution points for hands-on materials and printed matter, and will be able to provide up-to-date and accurate information about the program to teachers, parents, students, and community groups. In addition, some or all of the initial Outreach Centers may become regional centers, helping leadership teams in nearby cities and states to set up centers of their own and to conduct local teacher training programs. In short, the Centers will operate as the main liaison between people using the

program in schools, communities, and homes and the project staff in Newton. Particularly, people on staff at the Outreach Centers should be able to provide very helpful advice and assistance to the project staff at EDC.

As the program expands, however, we shall need to reach hundreds, and then thousands, of teachers in each city -- much too big a task for the project or even the Outreach Centers to undertake directly. Instead, we shall have to develop a mechanism that allows us to involve a great many teachers without calling for the intervention of project personnel with each individual. This suggests a process of teachers training one another, under the overall guidance and supervision of the project. To this end, we are considering the following model:

Classroom teachers (whom we can call T_1's) will receive their background in the program by attending workshops run by teacher trainers -- T_2's -- while the T_2's in turn will have worked with trainers of teacher trainers -- T_3's. Thus, a T_3 is someone who will have worked with us directly. Each T_3 trains a number of T_2's; and we feel that T_3's should spend at least some of their time working with children and classroom teachers directly so as to understand completely the situations that classroom teachers and T_2's will encounter. And again with T_2's: Once their own grasp of the program is complete, and after they also have used the program in the classroom, they will be ready to run workshops for classroom teachers -- T_1's.

The advantage of this arrangement is that each T_3 can reach many T_2's and T_1's, and each T_2 in turn can reach many T_1's, so that the number of qualified teachers can become very large quite quickly. (In principle, this is the same kind of exponential growth that in another context leads to population explosion, here turned to advantage.) Moreover, especially able T_1's can take on the role of T_2's or T_3's, and some T_2's can become T_3's. Through this overall mechanism, we expect to reach well in excess of 10,000 T_1's before the school year 1975-76, the first year that the entire series of 65 television shows will be available.

Several years ago, a similar model proved very successful in preparing teachers for a then-new high school physics course. There too, the course involved new curriculum, new pedagogical approaches, and a combination of audio-visual materials (film) and hands-on activities (in the form of laboratory work). Although there is little doubt that the approach is feasible, the scale on which we plan to employ it is probably larger than has been used in the past.

As the keystone of the teacher involvement process, the project will run a summer institute at its Newton facilities in July 1974 (and again in July 1975), inviting teams of participants from each of the six test site cities. Each team will develop plans for implementation and dissemination

in its own home city for the following year. Those invited will include elementary classroom teachers with potential for leadership in teacher training, administrative personnel from the various school districts (such as curriculum directors, mathematics supervisors, mathematics specialists, principals, assistant principals, supervising teachers, and staff members at the county and state levels), and college faculty members from each local area who are professionally interested in the teaching and learning of mathematics.

The project will run a similar institute in Newton in July 1975. Then, we hope to reach at least the 50 most important cities in terms of minority populations, and cities that can pay their own costs will be welcome in any event. At the same time as the Newton institute, there will be institutes at the six already-established Outreach Centers, now operating as regional centers by helping to train people from nearby localities. Again, this mechanism should enable us to train staff in a large number of cities quite quickly.

One important task of all these institutes will be to train some participants as T_2's and T_3's so they will be ready to work with T_1's in their home cities for the following school year. This later training of T_1's, coordinated through the Outreach Centers, will take the form of local inservice workshops run by "graduates" of the summer institutes.

The Outreach Center itself in some cities will probably tie in with existing education reform organizations, or it may exist as an entirely separate entity. A third possibility would be to share space with a college or university concerned with instruction of elementary school teachers in mathematics. A fourth possibility -- perhaps the most likely -- would be to operate in conjunction with a public school. A number of these options might be in effect simultaneously in a particular city.

The Center staff will consist of four full-time persons, along with another four employed on a part-time basis. The full-time staff will include a Coordinator in overall charge, a Community Worker primarily concerned with non-school uses of the program, a Technician to assist pilot classrooms with the installation and maintenance of television receivers and video tape equipment, and a Secretary who also may play an important role in public relations. On the part-time staff will be two classroom teachers and a university or college professor, all of whom have mathematics backgrounds and are specifically involved in teaching other teachers, and a Telecommunications Advisor qualified to help teachers make the best use of television in their classrooms and serving as liaison with suitable television broadcasting facilities. In addition, an Outreach Center might wish to retain consultants, who could assist local implementation of the project in several different ways. Some possible consultants might include artists, engineers, scientists, community workers, musicians, bankers, builders, business executives, etc.

The establishment of these local Outreach Centers will benefit the project in a number of distinct ways. We need the cooperation of teachers and school officials, and see advantages in a local base whose personnel are familiar with the educational and political climates in each city; also, we want the project to remain very accessible to people making educational decisions at the local level. We need centers for teacher training and for distributing materials -- two tasks that would be awkward to handle by remote control from Newton. Apart from the hands-on materials that we plan for the program (see below), we shall have to make arrangements for teacher-training films and printed materials for teachers, students, and parents that will be convenient to all users. Because we want to see the program used outside of school, we must reach parents, children, and community groups, preferably through existing channels. And we very much need feedback from a variety of sources. In some classrooms, we shall monitor what happens for ourselves, as part of the formative evaluation process -- also administered through the Outreach Center. But we need as well information from teachers not directly involved in evaluation, including those using the program informally; we need comments, criticisms and suggestions from interested individuals and community groups -- it is, after all, their children we are trying to reach -- and we must have a way of gathering impressions from school system administrators. In short, we see the

Outreach Center as an indispensable two-way communication mechanism, maintaining a flow of information back and forth between the project and its constituents.

There are two aspects of teacher training that give us particular concern. First, we are making arrangements for teachers to receive credit for their work with the project. What we plan to do is as legitimate an educational experience for teachers as it is for students. Second, we expect to influence both the content and methodology adopted by college and universities in their preparation of teachers for elementary mathematics instruction, on both pre-service and inservice levels. Our overall approach to mathematics has a number of advantages over more traditional curricula, and teachers might profit from it as part of their formal educations. The Outreach Centers will help to provide for both of these concerns, since the Centers will involve both Board of Education personnel and faculty members from various colleges and universities.

It will be important for the project to keep in mind throughout that the cooperation of certain key administrative personnel in each city is essential to the project's success. Overall, one function of the Outreach Centers will be to orient and acquaint these people and others -- including principals, assistant principals, other administrators, community groups, college and university faculty members, and potential co-workers -- with the goals and methods of the project.

The problems of school and community relations and teacher training are massive ones, but we must face them squarely (and early) if the program is to have any chance of real, lasting success.

Hands-On Materials

Active involvement on the child's part will be an important component of this program. Through the use of manipulable materials, children can explore and experiment with real objects and processes in ways that contribute to learning. Most contemporary learning theorists and developmental psychologists agree that interaction with the environment is an important -- perhaps indispensable -- part of the learning process. With television to help motivate children and to influence atmosphere and style, real materials can be a powerful way of bringing mathematics out of the abstract and into the child's own experience.

This notion received a great deal of support at our summer study; indeed, some participants saw the use of hands-on materials as the program's most useful and promising component, with television taking on only a secondary role. While many on the project staff believe the television shows will play a larger part than that, it is true that hands-on materials, carefully designed and properly used in the classroom, can lead to educational experiences not obtainable in any other way. There is little doubt that if a program of this sort were proposed for the college level, inclusion of

a laboratory would be almost automatic. But the need for active experience is just as great -- perhaps greater -- at the elementary level.

Most programs in the past that used hands-on materials to a large extent (including many EDC programs) have tended to be somewhat expensive to implement. As a result, while many school systems took up these programs enthusiastically and with excellent results, the programs by and large had little effect on schools and children within the larger American cities, where tight budgets have usually precluded their purchase. Thus, one of our tasks in this program is to make available materials that cost very little. Or, an even better approach would be to provide the right information and motivation so that children, teachers, and parents (but especially children) can find and assemble the items they will need.

At present, we plan to design activities involving three different levels of student participation in the preparation of materials. The corresponding materials we can refer to as Types A, B, and C. As one case, a school system could adopt the program entirely (or almost entirely) with materials that children find and assemble themselves and use in accordance with simple instructions from us; or we could help to provide certain "raw materials" at very low cost. Let us call this class of materials Type A. Another system could purchase packaged, commercially

manufactured materials -- Type C. At an intermediate level, we shall also make available some materials that need more preparatory involvement from the students than Type C does, but whose set-up requirements are less (and general appearance perhaps more attractive) than experiments based only on Type A materials. These would be Type B. The three categories are not mutually exclusive, however; there will be considerable overlap, and materials at the different levels would work well together. But a school system would have some options as to how much money it wished to spend in the course of adopting the program.

Concerning Type A, easily accessible materials, there is a large number of items around the typical home or school that provide for a surprisingly interesting and varied array of investigations. Some of these materials, such as soda straws, ordinarily are used for different purposes entirely, but lend themselves well to mathematically-oriented activities. Others, like empty milk cartons, are waste products with no other useful application. Still others, such as masking tape, the children will use more or less as the manufacturer intended.

The following is a list of Type A materials that might be useful in program activities both in classrooms and at home. Degrees of availability vary. Some items are nearly universal; others, while less common, can be obtained in quantity at very low cost.

MATERIALS THAT CHILDREN THEMSELVES CAN FIND IN QUANTITITES SUFFICIENT FOR INDIVIDUAL PROJECTS:

Newspaper; cardboard (cartons, cereal boxes, record jackets, etc.); drinking straws; milk cartons; toothpicks; aluminum foil; string; thread; coathangers; cardboard tubes (toilet paper, paper towel rolls); food products (corn starch, flour, salt, baking soda, beans, pasta); fabric scraps (discarded sheets and clothing); metal containers (coffee cans, "tin" cans, soft drink cans); plastic containers (foam and plastic coated coffee cups, detergent bottles, large bleach bottles); egg cartons, cardboard and foam; plastic (polyethylene sandwich bags, trash bags, wrappings of heavier guage, plastic wrap, old records, polyfoam pieces from packing, odd shaped styrene pieces from toys, buttons); wood pieces (popsicle sticks, clothespins, twigs); cellulose sponge; rubber bands; wax paper; soap cakes; calendars, bus schedules, supermarket ads; bottle caps, pop and screw top; sand, gravel, and pebbles; bobby pins; old playing cards; cancelled stamps; paper of all kinds.

MATERIALS THAT CHILDREN CAN FIND IN SMALLER QUANTITIES FOR GROUP PROJECTS, OR THAT THE PROJECT CAN PROVIDE AT VERY LITTLE COST:

Aluminum pie tins, TV dinner trays; heavy twine, bundling rope; baling wire; wood scrap (broom handles, fruit boxes, moulding scraps); sugar cubes; nails, tacks, straight and safety pins; miniature toys (cars, figures, airplanes, animals); rubber balls (3/4" to 3" diameter); road maps, subway maps; linoleum and tile scraps; paper plates; plastic forks, spoons, knives; wallpaper scraps; damaged bricks; rug scraps; styrofoam fruit trays; shoe laces; three-gallon ice cream containers; appliance knobs; zippers; yarn, ribbon, lace edging; curtain hooks and rods; checkers; parrafin; hair curlers; plastic fruit baskets; nylon stockings; one-gallon jars, glass and polyethylene; pill vials; broom straws; marbles; glue; masking tape; freezer tape; cellophane tape; used ballpoint pens; paper clips; rulers; plaster of Paris; tongue depressors; coffee

stirrers; pipe cleaners; batteries and bulbs; simple drawing compass; rope; plastic tubing; measuring tape; springs; mirrors; thermometers; colored gels; polarizing material; magnets; adding machine tape; plastic lenses.

Such materials might come into the classroom in two ways. The first is through the children themselves, bringing in what they find at home and elsewhere (with permission, of course). We intend to publish a book tentatively titled A User's Guide to Found Materials that will help children locate materials and will offer a great many suggestions for their use. The television shows will probably portray children at work with easily accessible Type A materials, and may provide some instruction in their use as well as suitable motivation. The second approach would have the project itself, working through the Outreach Centers in the various cities, buy certain materials in bulk for distribution to classrooms. These would probably not reach the classrooms in kit form, but would need sorting and counting by the children themselves. While this approach is not quite free, as materials brought in by children would be, most of the materials in the second list above are extremely inexpensive when purchased in large quantities. An absolute minimum of repackaging would help to hold costs down.

The category of easily accessible materials (Type A), whether located by the children or by the project, has the distinguishing feature that most of the items were meant originally for some use other than education. It is this, of course, that makes them inexpensive; because most are widely used to other ends, and so are manufactured in great quantity, their prices are generally low, especially in bulk. If one attempted to manufacture, say, drinking straws especially for educational use, the cost would run very high. But the country uses enough drinking straws anyway, apart from educational needs, that one can purchase them inexpensively.

The second category of materials that we intend to provide -- Type B -- consists of items not currently available for other purposes (or else available only through special outlets) that we could provide at relatively low cost and that would supplement Type A materials. These will cost a little more than Type A items because they will be produced on a far smaller scale, but we mean them to be within easy reach of most urban school systems.

Examples in the Type B category might include inexpensive graph papers (since commercial graph paper, being printed to very close tolerances for professional needs, tend to be too expensive for daily student use); graph papers specially pre-printed with axes and coordinates, which makes them much easier for beginners to use; games of many kinds that involve mathematics; play money, perhaps

printed in special denominations (-- for example, bills in denominations of thousands, millions, billions, etc. might help children to learn manipulation of very large numbers); polyhedra, printed out flat, that children can cut out, fold up, and assemble into more complex shapes; inexpensive rulers and measuring tapes; clear acetate sheets overprinted with grids as aids to estimation; the Walton 50-power cardboard microscope; and cardboard slide rules.

It is no accident that many Type B examples consist of printed materials. We intend this category for use in close conjunction with Type A (although Type A can operate well without them); hence, we shall have to impose severe cost restrictions on Type B designs. Taking into account both fabrication and distribution, printed materials by and large are the least expensive items to provide, while at the same time allowing for nearly unlimited versatility of design and application.

Special printed items such as those listed above, in combination with easily accessible materials from around the home, the street, and the school, should be able to provide very effective learning situations. And with the television shows to help make this kind of activity look very desirable to children (and to teachers and parents), impact of the total program used in this way should be strong.

The third category of hands-on materials -- Type C -- consists of manufactured packaged kits. We presently picture a kit as a large carton containing 30 or so small

"pacs," one for each child in the class, and a few items of larger or more expensive equipment to be shared by the class as a whole, along with books, posters, filmstrips, etc. All of the pacs in a kit need not be the same; it would be both practical and desirable to have a number of different but related activities going on in the classroom at the same time. A child who is finished with a particular pac would pass it on to another child, and begin working with another pac. The various pacs in a kit would all speak to the same basic mathematical concepts, but in different ways.

One particularly interesting possibility for the manufacture, assembly, and packaging of kits would involve some of the 500 or so rehabilitation centers located throughout the country. These facilities, employing people who are handicapped to varying degrees, are equipped for just the sort of light manufacturing the kits will require. Members of the project staff have visited one such center in New Haven, and concluded that the plant's staff and technical capabilities would have no difficulty in handling the kinds of kits that we have in mind. To provide a firm basis for comparison, the same staff members also visited the Instructional Materials Processing Center in Fairfax County, Virginia, a small organization run by the school system to handle manufacture, distribution, refurbishing, teacher training, and administrative support of a hands-on elementary science program involving every one of the County's 2000 elementary

classrooms. The kits produced by this Center are modeled very closely after EDC's Elementary Science Study, and reflect about the same level of complexity and technical sophistication that we intend for kits in the new program. The kinds of manufacture and packaging carried out by the Fairfax County operation could also be undertaken successfully by the rehabilitation facilities. Moreover, many rehabilitation centers are already tied administratively to local school systems, since the centers provide for the education of many handicapped children. The existence of this prior arrangement might provide an assist in distributing materials from the rehabilitation centers to the schools, and perhaps in setting up teacher training workshops as well.

There are well-equipped rehabilitation facilities in every major city and in many smaller ones, so it may be feasible to fabricate materials in the same cities that use them.

Aside from distribution through school systems, we hope to make materials available through commercial outlets (such as supermarkets) for children who watch the television shows at home. It may prove difficult to bring retail costs down to a point where nearly every parent can afford them. But by concentrating on distribution of Type B materials at first, and by encouraging children through the television shows to provide the more easily accessible items themselves, children at home should be able to augment their viewing with enjoyable and effective hands-on activities.

The many broad fields of learning and experience that use mathematics are rich in educationally valuable examples and illustrations. To make full use of these, we shall need to employ both television and manipulable materials. Both media can arouse and sustain a high level of interest and participation, and both lend themselves to absorbing, pedagogically effective presentations. While the television shows will "work" without the materials, and vice versa, the combination of these two media should be an especially powerful one.

APPENDIX A

CORE GROUP MEMBERS

Joyce Baynes

Edwin Campbell

Daniel Cheever

Sam Gibbon

William Hansard

Mitchell Lazarus

Robert Oliver

Judah Schwartz

Oliver Selfridge

Kevin Smith

Irvin Vance

Evans Whilby

Jerrold Zacharias

APPENDIX B

ML/ 7-9-73
Revised/ 10-3-73
Revised/ 12-28-73

PROGRAM OBJECTIVES:

A Preliminary Version

I. Mathematical Objectives

II. Heuristic Objectives

III. Other Objectives

NOTE: Detailed program objectives are not yet firm, and will doubtless change in the future. We earnestly solicit comments, criticisms, and suggestions from readers.

I. MATHEMATICAL OBJECTIVES

A. COUNTING AND ORDERING; NUMBER SYSTEM

1. Assumptions about Target Population

a. Can count from 1 to 1000, but have difficulty at decade boundaries; e.g., 29-30, 99-100, 499-500.

b. Can subtract numbers which are less than or equal to 10, if the remainder is positive.

c. Can add pairs of numbers whose sums are less than 20.

d. Have no concept of division, either conceptually or operationally.

e. Have some notion of multiplication, usually in the sense of repeated addition, and some notion of doubling and tripling small numbers.

f. Can compare numbers less than 100, but have some difficulty with numbers beyond 100.

2. Desired Outcomes

a. An understanding of place value: units digits, tens digits, hundreds digits, etc.

b. Multiplication and division by 1, 10, 100 etc.

c. Multiplication of numbers having only one significant figure; e.g., 20 x 30 = 600.

d. Rough calculation by approximation, e.g., 39 x 41 ≈ 1600. Also, an acceptance of approximate results as useful, even though not exactly correct. (This amounts to breaking down the strict dichotomy between right answers and wrong answers.)

e. Addition, subtraction, multiplication, and division (?) of two-digit numbers.

f. Multiplication table to 10 x 10.

g. Squares of numbers 1 through 12, 15, 20, 25.

h. Conceptual understanding of simple, common fractions: halves, thirds, quarters, and fifths.

i. Comfortable handling of very large numbers, up to hundreds of millions; "scientific" notation; e.g., 10^6 for 1,000,000.

j. Certain techinques for checking the results of long computation. (Children may find these useful in test situations and in arithmetic classes.)

3. Some Examples

a. Simple, inexpensive slide rules for addition/subtraction and multiplication/division.

b. Multiplication via counting of rectangular arrays; also demonstrates commutativity of of multiplication (3 x 4 = 4 x 3).

c. Multiplication tables through songs or rythmic chants.

d. Fractions through fracture and reassembly of manipulable objects; e.g., uncooked spaghetti.

B. MEASUREMENT

1. Assumptions about Target Population

a. Know that a pound is a unit of weight.

b. Know that inch, foot and mile are units of length or distance.

c. Have little concept of how much a pound is, how small an inch is, or how far a mile is.

d. Recognize some measuring instruments, such as ruler, measuring tape, clock, thermometer and scales, but do not know how to use them quantitatively.

2. Desired Outcomes

a. Understanding what it means to measure length, weight, time, temperature, and angle in numbers.

b. Rudimentary skill in these five kinds of measurement.

c. An understanding of the role played by units in measurement.

d. Familiarity with convenient metric units; i.e. knowing roughly how long a centimeter and a meter are, how hard it is to lift a kilogram, how long a second and a minute last, and how much is in a liter.

e. Some conversions among metric units; millimeter/centimeter/meter/kilometer; gram/kilogram/metric ton; second/minute/hour/day; milliliter (cubic centimeter/liter.

f. Some notion of area and volume, and the fact that these can be independent of boundary shape.

g. Preliminary ideas about rates of change; e.g., miles-per-hour as a unit of measurement.

3. Some Examples

a. Establishing the necessity of measurement, and of consistent units, through humorous skits.

b. Film footage of surveyors, pharmacists, scales that measure the weight of loaded trucks, meteorologists, grocers, athletes and coaches, chefs, tailors, people who lay carpets and floor tiles, carpenters, plumbers, physicians and nurses, ...

c. Measurements over many different orders of magnitude; e.g., one could measure the distance to the moon in millimeters, or the "weight" of the earth in grams, or the width of a desk in kilometers.

C. ESTIMATION

1. Assumptions about Target Population

a. Have some ability to estimate qualitatively; e.g., which is farther, the distance to the moon or the distance to New York City; who can throw a ball farther, you or Joe Namath; who is taller, you or Wilt Chamberlain; which is heavier, a penny or a quarter?

b. Can estimate ratios of small numerical value: given a cup and a quart of orange juice, can estimate the number of cups in the quart.

c. Have difficulty in estimating large quantities, especially in small units; e.g., how many inches long is a football field?

2. Desired Outcomes

a. The ability to estimate length, weight, time, and temperature over commonly-encountered ranges of magnitudes.

b. The ability to estimate numbers of objects.

c. An understanding of power-of-ten notation from 10^{-9} to 10^{9}, and an appreciation of its usefulness in handling very small and very large numbers.

d. An acceptance of estimates as useful data, even though not exactly correct.

e. The courage to guess.

3. Some Examples

a. Introduction of the prefixes mega, kilo, milli, and micro to facilitate estimates of large and small quantities, ("There are about 2 megapeople in the Boston area, and about 200 megapeople in the United States.")

b. Inappropriate units to humorous effects: "I am writing on 10 microacres of paper."

c. Estimates that require still other estimates: "How many supermarkets are there in the United States?" (How many people shop at each supermarket?)

d. "Ridiculous" problems: How many bedbugs in the city of Chicago?

e. Film footage of people who use estimation in their work; e.g., bartender pouring ingredients into a shaker "by eye" then emptying the shaker by filling a glass exactly to its brim.

D. MAPPING AND SCALING

1. Assumptions about Target Population

a. Can recognize pictures and drawings of objects which range roughly from 1/100 to 100 times human size.

b. Can follow simple directions, e.g. -- Put an 'X' in each circle and a 'Y' in each square.

c. Know left and right, and up and down.

2. Desired Outcomes

a. Understanding maps as special kinds of pictures.

b. The ability to draw and interpret simple maps.

c. The ability to "follow" a map, such as a street map or road map.

d. The ability to use maps quantitatively; understanding scale.

e. An appreciation of a scale model as a kind of map.

f. The ability to compare and relate different "views" of a three-dimensional object.

3. Some Examples

a. Relationships between an aerial photograph (or the view from a tall building) and a city map.

b. Contour maps; e.g., a contour map of a person's face.

c. Floor plans and elevations (side views) of houses, apartment buildings, and schools.

d. Satellite photographs compared with world maps and globes; curvature of the earth.

e. Navigation in a jet airliner or spacecraft.

f. Maps of the same scene, but to drastically different scales: from floor plan to diagram of solar system in about 12 stages.

E. GRAPHING

1. Assumptions about Target Population

None

2. Desired Outcomes

a. An understanding of number line, and of crossed number lines (rectangular coordinates).

b. The ability to make and interpret simple record-keeping graphs of processes that take place over time, such as outdoor temperature over a day.

c. The recognition of elevations (e.g., the side view of a mountain) as one form of graph, especially when the horizontal and vertical scales are different.

d. A rudimentary understanding of rates, as they appear in graphs.

3. Some Examples

a. Temperature against time. (This example has an interesting property. A plot that shows an entire year of temperatures for, say, Boston, will look like a thick, irregular line cycling through the seasons. But if one zooms in to examine a small portion in detail, there then appear smaller cycles corresponding to individual days.)

b. Temperature against distance: variation in temperature at a particular time in winter, along a line running from Bangor, Maine to San Diego, California.

c. Heights of plants or people against time.

d. Population growth in graphical form, with extrapolations.

e. Film footage of a flat-bed plotter (drawing something interesting) to illustrate rectangular coordinates in two dimensions.

f. An overhead traveling crane (also called a bridge crane; the type often seen in scrapyards): rectangular coordinates in two and three dimensions.

g. A modern Swedish-type construction crane: polar coordinates in two dimensions and cylindrical coordinates in three dimensions.

h. A conventional mobile crane: modified spherical coordinates.

i. Lines of latitude and longitude: spherical coordinates.

j. The work of an aircraft controller: locating airplanes in a coordinate system -- a life-and-death application of graphing principles.

k. Hypothetical cities (or real ones, if they are clean examples) laid out in rectangular and polar grids.

II. HEURISTIC OBJECTIVES

(NOTE: This represents only a tentative beginning. To reduce the list of heuristics in the proposal to a workable set of program objectives will require a great deal of careful work, augmented by the thoughtful observation of many children. In the meantime, and in the interests of a rapid start-up, it might be best to regard the heuristic objectives as secondary to the mathematical objectives outlined above.)

1. To check a problem for inherent reasonableness and consistency. No amount of searching will find a strategy for drawing a four-sided triangle, or for traveling from New York to London over land.

2. To have the courage to guess at a solution, knowing full well in advance that this first solution will most probably be inadequate. How could we solve the traffic problem in Boston? "Ban all vehicular traffic" is not a practical solution, but it might be a good first try.

3. To have the knack of examining poor answers in search of better ones. Just why is it impractical to ban all vehicular traffic in Boston? (Make a list.) Is it possible to meet these objections (or most of them) with only a little traffic?

4. To examine order of magnitude, quickly and automatically. How many cars are there in Boston now? How many might Boston streets easily tolerate?

5. To recognize that situations often appear very different when seen from different points of view; to feel comfortable trying out different points of view. (This is a heuristic with strong social implications.) Traffic flow looks very different to (a) an observer standing beside the roadway; (b) an observer in a moving car caught up in the traffic pattern; and (c) an observer in a helicopter overhead. Different views may show different degrees of orderliness and usefulness.

6. To accept the notion that most real problems do not have predetermined "right answers," and that a workable solution is usually a compromise among many factors.

III. OTHER OBJECTIVES*

In addition to the mathematical and "heuristic" objectives treated in detail above, we have in mind a few additional, informal, goals for the program. Because these will be difficult to evaluate rigorously, we hesitate to list them as formal objectives; rather, we prefer to consider them as intellectual side-effects that may accrue to the target population if we go about the program properly.

We refer to matters of personal and intellectual style. This includes such traits as curiosity, initiative, and intellectual honesty -- the characteristics of a student willing to take an active part in his own education, rather than just absorb passively whatever he hears. The program must convey the point that "right answers" need to be sought out and confirmed; there is no secret knowledge to which teachers have access and students do not. Information is available to anyone who looks for it, whether in books or in experiments. We must show students how to find information on their own, and encourage them to do so.

To be consistent with this aim, the program must also encourage children to be a little critical of what they read and hear. The fact that an adult -- even a

---

* Extracted from Working Draft 3 and Changes and Additions to Working Draft 3.

teacher -- says something does not necessarily make it true. And many children do not realize that books are occasionally wrong. A little doubt and skepticism can be very healthy, intellectually, since the child who doubts is likely to try thinking matters through for himself. This has long been a cardinal principle in college education, but the arguments in its favor apply with equal force to elementary school. Of course, this has implications for the proposed program itself: Children should be encouraged not to take televised material on faith, but should have a certain degree of skepticism about that too. Where intellectual matters are concerned, no authority is absolute. The young, as well as their elders, should have the privilege of doubt.

To the same end, we plan to share with viewers some of the problems that no one has been able to solve. It is not known, for example, why snowflakes take on their beautifully symmetrical shapes, or how some species of migratory birds manage to navigate over journeys thousands of miles long. We intend to be open with children about the fact that adults do not have all the answers. It is our experience that this approach often helps to stimulate the children's involvement.

We wish to foster an atmosphere of collaboration, especially between students and teachers. Children generally respond very well when an adult says, "Let's see if we can

work this out together." Student-student interactions also can be extremely valuable, if classroom conditions make it practical. In general, we shall support the point of view that communication among individuals, apart from filling social needs, is important to intellectual pursuits.

These aims will not be part of the program's formal content. They are criteria that will affect our manner and style of presentation, influencing not so much what we teach as how we teach it.

* * *

School experiences can have important effects on a child's self-esteem. In particular, a sense of inevitable failure can be especially damaging. One aim of this program is to break the vicious circle of failure and discouragement that many minority children encounter in mathematics; this might enable some children to go much farther with mathematics in the rest of their education than they otherwise might.

The program could contribute to self-esteem in another way also. Mathematics has the reputation of being difficult. Accordingly, a child who succeeds with the new program (and we expect that most will) is likely to gain an improved estimate of his own intelligence and ability. This in turn might have desirable effects on other aspects of the child's life. To a child accustomed to failure, a little success can go a long way.

Finally, we hope that the program will be of some benefit socially. For example, television segments will show black, Spanish-speaking, and white children engaged in productive cooperation that appears to be spontaneous and uncontrived. Minority persons who appear in the television segments will act and speak like people whom the audience sees every day. The frequent use of minority actors, minority cultural settings, and minority art forms may help children to build up opinions and feelings about their own heritages. The program will not try to obliterate the differences among various groups; rather, it will demonstrate the mutual acceptance of these differences. Hopefully, the overall effect will make it easier for children to interact with one another in comparable ways.

APPENDIX C

INTERNAL ADVISORY GROUP

Erma Brooks	Follow Through Project
Charles Brown	Training Center for Principals
Juliet Brudney	Career Education
Edwin Campbell	Administration
John Churchill	Arithmetic Project
John Coleman	Accounting
Mattie Duckens	Social Studies Project
Christopher Hale	Elementary Science Study
Janet Hanley	Social Studies Project
Robert Hayden	Career Opportunities Program
George Hein	Follow Through Project
Grace Hilliard	Follow Through Project
Adeline Naiman	Administration and Publications
Gilbert Oakley	International Programs
Donna Marie White	Follow Through Project

APPENDIX D

BITS AND FORMATS SESSIONS: PARTICIPANTS

July 23, 24, and 25, 1973

Arthur Bardige	Educator
Juan Caban	Educator
Alice Childress	Writer
Marian Parry Feld	Illustrator
Donald Fouser	Producer
Clark Gesner	Writer
Herbert Ginsburg	Psychologist
Ellis Haizlip	Producer
Jerome Hausman	Agency Representative
Ezra Heitowit	Psychologist
Romona Jones	Native American Specialist
Douglas Lapp	Educator
Michael Narosny	Educator
Christopher Sarson	Producer
Joan Shigekawa	Producer
Julio Torres	Producer
William Walton	Educator
Newton Wayland	Musician
William Zayas	Producer

July 31, August 1, and 2, 1973

Arthur Bardige	Educator
Juan Caban	Educator
Colin Carew	Producer
Marian Parry Feld	Illustrator
Donald Fouser	Producer
Romona Jones	Native American Specialist
Phillip Morrison	Physicist
Michael Narosny	Educator
Elliot Noyes	Producer
Christopher Sarson	Producer
Julio Torres	Producer
Newton Wayland	Musician
William Zayas	Producer

APPENDIX E

RECOMMENDATIONS

We perceive a We-They relationship with authority and content being determined by all white people and an insensitivity to the feelings and needs of minority people within this group. We recommend that all such meetings, decision-making power and leadership roles be shared and evident with the minority groups.

To implement this we recommend:

1. That whites have race awareness training.
2. That there be minority group representatives at the academic content level, more than one, a majority number which reflects the target population.
3. That the TV series hire a minority group member as Executive Producer.
4. A mechanism for hiring be set up such that the decision who is competent be made by the representatives of the target population.
5. The majority of the program staff be members of the target population who through experience and participation are competently aware of content needs.
6. We realize the limitations of $4.5 million, the budget, does not exclude providing a career-ladder training program for minorities in mass communications in this project.
7. We believe that these recommendations be dealt with before proceeding any further with this program.

We are asking that a progress report detailing your actions and responses to our recommendations be made to us within 15 days.

APPENDIX F

E|D|C

EDUCATION DEVELOPMENT CENTER

December 6, 1973

To: Arthur Bardige
Juan Caban
Alice Childress
Marian Feld
Donald Fouser
Clark Gesner
Herbert Ginsburg
Ellis Haizlip
Jerome Hausman
Ezra Heitowit
Elam Hertzler
Romona Jones
Douglas Lapp
Michael Narosny
Joan Shigekawa
Julio Torres
William Walton
Newton Wayland
William Zayas

From: Jerrold Zacharias JRZ.

This memorandum will serve as a belated reply to the July twenty-fifth presentation of the minority caucus group -- belated, because I wanted to have some accomplished facts rather than just pious promises to report.

The National Advisory Committee to the (still nameless) Math TV project had its first meeting on November first. Among the items we discussed with the committee were staff commitments made to date, present staff needs, and plans for filling these positions with a special emphasis on minority representation. It seems appropriate and timely at this point to make a similar report to you.

As things stand now, overall responsibility for running the project is vested in a group of three: Leroy Colquitt as managing director, Christopher Sarson as executive producer, and myself as project director. Colquitt joined the project full time in mid-September. Sarson, however, can give us only one-fifth time until the first of the year, since he must finish his commitment to WGBH as executive producer of Zoom.

Evans Whilby, whom you probably met in July, is project coordinator and works directly with Colquitt. We still need a business manager to round out the administrative team.

The problems relating to schools, teachers, parents, and the general pubiic are the responsibility of Irvin Vance. It is our great good fortune that Vance has had prior experience both as a mathematics educator and an "outreach" director. However, he does need additional help even in early arrangements with the six cities now participating in our testing and feedback

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program. (The six cities are Atlanta, Boston, Hartford, Los Angeles County, New York, and Oklahoma City.)

Joyce Baynes and her staff (Pamela Almeida, Melanie Barron, Geraldine Brookins, Sherryl Graves, and Barbara Quiroga) are setting up the preliminary assumptions testing and feasibility phases of the program so that minority children will themselves have the final say about the programs. Unfortunately for us, Joyce insists that she does not want to be in charge of the evaluation operations over the long term, and we are therefore seeking someone to succeed her in that role. She will, however, remain on the research and evaluation staff. Dalton Jones, a psychologist at the University of Massachusetts at Amherst, spends one-fifth of his time with the research and evaluation aspects of the program.

Mitchell Lazarus, now designated director of content and publications and assisted by Swaroop Bhide, continues to carry a multitude of writing loads. We all agree that the project needs first-class reports and proposals to bring in the financial support for outreach, evaluation, hands-on materials, tests, and so forth. I believe my estimate that we are only half funded is correct.

Christopher Sarson has been producing Zoom on public television for the past two years. The size of that program's audience and the success of the format he designed testify to his sensitivity in evaluating and satisfying the needs of the audience he chose for Zoom. Now he has a different audience, and we on the project are convinced that he has the sensitivity to choose minority staff members who can satisfy the needs of this audience new to him. Starting in December he is looking for production personnel. Rather than try to paraphrase his guidelines, I attach that part of his guidelines germane to this memorandum (Page F.4).

I also attach, (Page F.5), a marked copy of a page sent to us by the Office of Education to indicate to us those parts of the Emergency School Aid Act which affect the cultural bases of our project. Naturally, as with all legislation, the spirit is as important as the letter of the law. The emphasis of the Act is on integration, and my own reaction to Sec. 702(b) is to make the bold assumption that if we target our programs and materials to minority groups, then they will also be appealing and useful to the majority of children.

One final note. There always arises the question of who has the last word in the decision making process. In our case, this responsibility rests with the project director, the managing director, and the executive

producer. But there are many important decisions which must be made that could not be classed as policy decisions. These decisions must also involve taste and judgment in content materials, how they are presented, who presents them on screen, and to whom we listen. Clearly, the children have the final say, and our arrangements are being made so that almost all of the children whose reactions influence the program belong to minority groups.

Copies to:

Pamela Almeida
Melanie Barron
Joyce Baynes
Swaroop Bhide
Martha Booker
Geraldine Brookins
Edwin Campbell
Leroy Colquitt
Stella David
Samuel Gibbon
Sherryl Graves
William Hansard
Dalton Jones
Fred Kresse
Mitchell Lazarus
Shirley Lemay
Marian Moffett
Robert Oliver
Barbara Quiroga
Margaret Robinson
Christopher Sarson
Judah Schwartz
Kevin Smith
Lally Thomas
Irvin Vance
Evans Whilby

GUIDELINES FOR THE HIRING OF PRODUCTION STAFF

I. Policy

. . . . .

In addition, we expect any producer, writer or assistant, whether staff or freelance, to bring a sensitivity of the needs of our minority audience to his or her aspect of the production. And we appreciate that a minority producer, writer or assistant will bring a knowledge of the background and heritage of our target audience, which is vital to the success of the project.

II. Procedure

As of November 1, 1973, we have no clear idea of the form of the finished programs.

The likelihood is that there will be 65 programs consisting of some 600 or so "bits" produced independently, and coordinated by key staff members at EDC.

We have not yet decided whether these "bits" will be produced in Boston or elsewhere. And we shall not decide until Christopher Sarson, the executive producer, William Hansard, his assistant, and Evans Whilby, the project coordinator, have made a thorough survey of all forms of potential minority talent. This survey is now underway.

By March 1974 we shall have decided whether to employ personnel on a full-time, part-time or freelance basis; and the majority of jobs will have been posted by then.

Positions with job descriptions will first be posted on the Math TV project noticeboards to give people on the project a chance to apply. After a few days we shall attempt to reach a large number of potential applicants. Applications of key staff will be reviewed, and appointments made, by the Executive Committee.

III. We recognize that in the past minority people have not had the opportunity to express their talent in the specific fields we are interested in -- television producing, writing, directing, acting and production assistance. And so we recognize that it is unrealistic to look for demonstrated talent. Rather we are looking for potential talent. Has a minority person shown creativity, flair, and the ability to accomplish in his or her present field? Is there a likelihood that this talent can be applied to television? These are the criteria by which we shall judge a prospective employee.

IV. Salaries

Salaries will be paid according to accepted industry practices. EDC is an Equal Opportunity Employer, and does not discriminate.

TITLE VII—EMERGENCY SCHOOL AID

SHORT TITLE

SEC. 701. This title may be cited as the "Emergency School Aid Act".

FINDINGS AND PURPOSE

SEC. 702. (a) The Congress finds that the process of eliminating or preventing minority group isolation and improving the quality of education for all children often involves the expenditure of additional funds to which local educational agencies do not have access.

(b) The p[illegible]e of this title is to provide financial assistance—

(1) to m[illegible]e special needs incident to the elimination of minority group segregation and discrimination among students and faculty in elementary and secondary schools;

(2) to encourage the voluntary elimination, reduction, or prevention of minority group isolation in elementary and secondary schools with substantial proportions of minority group students; and

(3) to aid school children in overcoming the educational disadvantages of minority group isolation.

EDUCATIONAL TELEVISION

SEC. 711. (a) The sums reserved pursuant to section 704(b)(2)(B) for the purpose of carrying out this section shall be available for grants and contracts in accordance with subsection (b).

(b)(1) The Assistant Secretary shall carry out a program of making grants to, or contracts with, not more than ten public or private nonprofit agencies, institutions, or organizations with the capability of providing expertise in the development of television programing, in sufficient number to assure diversity, to pay the cost of development and production of integrated children's television programs of cognitive and effective educational value.

(2) Television programs developed in whole or in part with assistance provided under this title shall be made reasonably available for transmission, free of charge, and shall not be transmitted under commercial sponsorship.

(3) The Assistant Secretary may approve an application under this section only if he determines that the applicant—

(A) will employ members of minority groups in responsible positions in development, production, and administrative staffs;

(B) will use modern television techniques of research and production; and

(C) has adopted effective procedures for evaluating education and other change achieved by children viewing the program.

APPENDIX G

BITS AND FORMATS: COMPILATION OF IDEAS

This is a collection of television ideas from the summer study Bits and Formats meetings. Most arose during small-group sessions involving about 5 to 7 people apiece. Of these groups, each included at least one television producer and at least one person thoroughly conversant with the project's mathematical objectives, the others having a mixture of backgrounds. One participant in each group took on the responsibility of making the notes from which this Appendix derives. (A small fraction of the ideas reported here predate the summer study; we include them so that production staff will have a compilation available in one document.)

Organization of the ideas below comes under 7 major headings, of which the last 5 represent the program's main mathematical objectives.*

1. Major format ideas -- long-term concepts that could recur from show to show.
2. Miscellaneous -- ideas that do not readily fall under any one of the next 5 mathematical topics; also includes some broad considerations that may apply to many different segments.
3. Decimal number system; mathematical symbols; properties of numbers.
4. Measurement; units of measurement; metric system.

---

* See Appendix B for details on objectives.

5. Estimation

6. Mapping and Scaling; point of view

7. Graphing

Segments relating to the program's problem-solving (heuristic) objectives run through all of these topics.

These were brainstorming sessions, with an emphasis on rapid production of many ideas rather than selection and refinement of a few. As a result, the quality and appropriateness of the entries here varies over a wide range. Also, the degree of development is far from consistent: Some ideas would need a great deal more work than others before they could be implemented. In the interests of a complete report, however, we have retained almost every suggestion appearing in the notes of the groups' record-keepers. The only omissions are one or two items that strain the bounds of good taste, and a very few that, for whatever reason, we felt were singularly inappropriate to the program.

This document might well serve as the nucleus of a permanent, ongoing collection of possible bits for television shows.

SECTION ONE

MAJOR FORMAT IDEAS

1.1 The Club : Group of inner city kids with basement workshop/clubhouse, who solve problems in their environment using quantitative and heuristic methods. This emerged as a flexible and believable major format which could be used to introduce hands-on projects (with found materials), heuristic approaches to problem-solving, and various games. The discussion gave consideration to the set, the makeup of the group, what they would do/make, and where they would get materials and information. The basement set and possibly the adjoining alleyway could easily be built in the studio. There would also need to be some location shooting.

Ideas about what the group should do developed at first out of a parent format idea: a children's Mission Impossible organization using quantitative methods to solve problems. These could include finding an appropriate symbol or logo and reproducing it geometrically; making dashikis for the group, measuring the cloth and making patterns; making an electrical combination lock or a burglar alarm for the clubhouse; putting up a basketball court in the alleyway and making it of regulation size. An old woman, perhaps a member's grandmother, needs some way to let her cat in and out without climbing several flights of stairs. The group works out a basket, rope, and pulley arrangement on her fire escape and this involves measurement, diagrams, etc. Materials and information acquisition should be presented in a realistic way; that is, other kids should be able to duplicate the process without too

much trouble. Any profit-making enterprises the group is involved with should be realistic as well. It was thought that the group should regularly seek some help from adults, and aside from parents it seemed valuable to develop sustained relationships with elderly people. One example might be the man who owns the candy store/bookshop. (It was decided that a newstand would realistically contain printed matter aimed at other target populations.) As an inner city library surrogate, the bookshop could provide reference materials readily available to everyone and teach resourcefulness in using them. Moreover, this format could be fairly realistic with physical, political and moral issues and present a wide variety of quantitative and behaviorial alternatives while maintaining levels of adventure and intellectual stimulation to make it successful with the target population.

1.2 Straight Arrow: A long format introducing a realistic Native American who teaches kids about the mathematics found in nature and in Native American culture and artforms. Partly inspired by "Straight Arrow" cards which used to come in Shredded Wheat boxes, this format suggests a similar series of printed instruction cards with local materials dealing with survival in the woods and Native American crafts. The format itself might be built around a Native American who lives in the city and is a construction worker. His job could be the subject of some bits, but most would deal with weekend trips with his family to a reservation or to various wilderness settings. There, he would teach his children about such things as how to tell the difference between fir, spruce, and hemlock by the shape and config-

uration of the needles, geometry in the construction of a lean-to or tipi, why the softness or hardness of wood relates to the shapes of trees, annual rings in trees, etc. Also. . .
Tracking: estimating size of animal; enormous tracks from snow melting around them; animal walking, running. Rock formations; crystals in rocks. Trilium (spring flower) with three petals; other flowers with other symmetry. Firemaking: structure of sticks for fire: structures for camp cooking.

1.3 "Alice in Wonderland" - "Phantom Tollbooth": Imaginary world entered by dream, door, mirror, TV screen, etc. using same entry for each show. Active kids represent voice of authority, adult world represented by comical monsters, etc. Present various kinds of disorder and mixup with comical overtones, then reinforce logic of math operations after exit in real world situations, much to 'Alice's' relief. Dream adventure involving inflation of objects with bike pump, then returning to kitchen for discussion with mother about inflation of food prices. Fantasy street scene with everyone in little cars; one way streets which travel in circles. Use of costumed characters from different time periods and fairy tales. Kids finally work out map of streets to get from one place to another. Later, in real situation, they help parent negotiate one way streets.

1.4 Machine shop: appropriate format for measurement, mapping and scaling (plans) geometric properties of solids (cylinders from rectangular solids in a lathe), decimal equivalents, tolerances, principles of vernier scale.

1.5 Circus: tent structure (tension and compression), juggler, tight rope walker; how much does the elephant weigh? why does tight rope walker use long pole? center of gravity (2 forks and a cork balance); acrobatic teams--measuring heights of stack of acrobats.

1.6 Quiz show format: "Score" -- kids in two groups, one acting out a story and the MC asking math questions to the other group, charades style; when a right answer is given, lights, loud gong SCORE!

1.7 Geometry in the kitchen: Kitchen set; Sections of carrots to make discs, rearrange to get strange or real taper; sections of carrot taken long way. Cuts through complex onion, artichoke, etc., to bring out different views. Making of cubes, pyramids, tetrahedra, what-not with knife and vegetable. Imaginative use of context--the flower bud to show the five points of the apple, staff of seeds seen on transverse cut, etc. Volumes, units, areas (pie crust) and many other concerns can surface here.

1.8 Rock group: trios and quartets; losing one member; sound space factor; sound studio, decibels of sound; measuring circumference of record; what percentage of earnings should sound helper get? How can practice room be made more soundproof so neighbors won't complain? Investments and how to divide earnings.

1.9 Kids running or touring a radio station: Record/tape speed; tape speed time chart; frequency; antenna height and configuration, signal shape; wavelength; strength of signal and effective receiving area; what happens to reception at night? How long is a record groove/(trick question: how many grooves in a record?)

tangency of tone arm; does needle travel at the same speed on outside and inside of record? how does this effect microscopic view of groove? How many light bulbs would the power output of the big transmitter light?

1.10 Fairy tales up-to-date: Dicken's The Magic Fishbone as a model: situation in which the characters use math shortcut to solve the problem.

1.11 "Ocdomi spider stories". Native American spider character; the stories are traditionally used for teaching a wide variety of things in an indirect fashion.

1.12 Four children, aged 10-11, comprise the entire crew of a sophisticated spaceship in a time when travel of this kind has become completely practical. The ship operates in largely unexplored reaches of space, independent of any adult authority. Because they are usually out of touch with their base due to the great distances involved, the group must make its own decisions and cope with its own crises (of which there is no shortage). Their mission is to explore and investigate, to be generally helpful to civilizations they encounter, and to render emergency aid to anyone who needs it. More on this below.

The familiar locale is the spaceship's bridge, or control room: a circular room about 10 meters across with a slightly domed ceiling. In the center of this room are four large, heavily upholstered chairs facing outwards from the middle in four directions. The

chairs automatically recline for high acceleration and are fitted with all kinds of useful gadgetry. Directly in front of and overhanging each chair is a compact instrument panel; across from each chair is a large viewing screen. The four screens serve a variety of purposes: they act as windows via television linkages; they can show scenes in the vicinity of the ship (with the option of extreme magnification for examining planetary surfaces, etc.); they provide some of the ship's instrumentation readout, and -- important for our purposes -- they display output from the ship's computer.

The crew consists of two girls and two boys, in uniforms that are similar except perhaps for color. There are no distinctions of rank among them; they are all equal in principle, although different pecking orders tend to arise in different situations. As a rule, the person whose special abilities are most appropriate to the situation is in charge for the moment. Each has a specialty -- pilot (or helmsman), navigator, "science officer," and engineer --but each can perform any of these jobs with at least minimum competence. In particular, they all tend to work closely with the science officer, whose task is basically one of identifying all kinds of unknowns. Their individual traits are such that the absence of any one is something of a handicap to the rest.

Lucille is the pilot; she is bright, witty, something of a chatterbox, and extremely likeable. Of the four, she is most effective at negotiating with both friends and enemies, and is unofficially the "diplomat" for the group. She has talked her way out of many difficult situations. Also, her ability to do

rough calculations very quickly in her head is often helpful when time is short. She sometimes jumps to conclusions, however, and may act without taking into account all of the relevant facts.

Rick, navigator, speaks with a Spanish accent. Ordinarily the quietest of the four, he is nonetheless the one who most often takes charge in a crisis. He is the quickest to face facts, to recognize what needs to be done, and to set about doing it. His navigation is always utterly reliable; he works through his mathematics (and everything else) with extreme care, and is sometimes irritated by Lucille's "slapdash" estimates which he regards as hopelessly imprecise. Rick and Lucille occasionally fall into petty arguments.

Greg, the science officer, is black. Very much the intellectual and widely read, he loves to construct and defend elaborate theories -- which occasionally have obvious defects, to the others' amusement. He is extremely curious, sometimes taking what the rest regard as unwarranted risks in order to investigate a new and particularly interesting phenomenon. In some respects, he is impractical; his goal is to understand, not to put into effect. This sometimes frustrates the rest of the group, but his ability to quickly analyze novel and complex situations is invaluable to them.

Susan is the engineer, a born tinkerer. Any sort of machinery or gadgetry fascinates her. She has a very high respect -- almost an affection -- for the ship's equipment, spending much of her free time installing minor improvements. (However, some of her

constructions have a definite Rube Goldberg air.) Her intuition for what will and will not work is excellent, sometimes leading to premature impatience with Greg's theoretical discussions. Mathematics on paper bores her, but she is very adept at mathematics in the form of hardware. Her philosophy is pragmatic, and she sometimes takes a short-sighted view. She and Greg have in progress an endless chess tournament.

The fifth important "character" is the ship's computer. Its capabilities and modes of operation are well suited to the program's purposes. For example, the computer speaks and understands a simple form of English, so the crew can communicate with it quickly and easily. When in use, it operates rather slowly, one mathematical step at a time, and it always writes out its computations on one of the viewing screens on the bridge, usually in sophisticated color graphics; it uses the screens as a human might use a scratch pad or blackboard, The crew generally watches the display and kibitzes. As appropriate, the computer might present text, graphs, diagrams, or any mixture of these, using color for clarity and motion for effect.

Although the computer can be "programmed" orally, it does not understand English nearly as well as a human would. Specifically, it will decline to act on statements or instructions that are vague, ambiguous, or incomplete. Depending on the circumstances, it may ask for clarification; rephrase and request confirmation; reject an instruction outright (and say why); or misinterpret altogether. Thus, the development of a clear and workable

problem statement often takes the form of a dialogue between the crew and the computer, with the computer's limitations requiring the crew to progressively clarify their thinking. Once the problem is specified to the computer's satisfaction, the solution is sometimes obvious. The computer may draw diagrams on the viewing screens during the conversation; and the crew may put forward corrections and suggestions for changes. When time is short -- as it often is -- these interchanges become very tense. At other times, they can be realxed and humorous.

The computer never suggests heuristic ploys, but can readily incorporate them into the developing model as they occur to members of the crew. Because crew members tend to think in somewhat different ways, the four typically offer different kinds of problem-solving strategies.

The computer's voice is completely unmodulated and "mechanical sounding." There is a consistent set of commands for activating it, for accessing its encyclopedic memory (it also serves as the ship's reference library), for initiating execution of a properly-stated problem, and for deactivation. Ordinarily, the computer shows little initiative and no creativity, but it occasionally offers unsolicited observations, usually to humorous effect. Lucille tends to treat it as she would a person (unsuccessfully, as the computer takes statements literally); Rick is efficient and businesslike with it; Greg is forever probing its capabilities and offering it paradoxes. Susan tinkers behind its cover plates to the others' apprehension.

The computer has no visible control panel or input devices. All communication with it is via voice and the large viewing screens. And the computer has no direct control over the ship's equipment. The ship is heavily mechanized -- controlled entirely from the bridge, except when things go wrong -- but not automated.

There is no armament in the ship. The crew must cope with crises by their tools, their persuasiveness, and their wits. Force and threats of force are not acceptable techniques for handling crises.

This is primarily an action/adventure series. Mathematics and science, although playing a consistent part, are always means to other ends; the resolution of critical situations faced by the crew or by others with whom they have become concerned. The foes they meet most often in their travels around the galaxy are disease, famine, pestilence, and war, all except the last affecting persons (both human and alien) other than themselves.

The crew has human and alien friends of long standing whom they visit from time to time, and they have long-established enemies as well -- civilizations which consistently seek to exploit and intimidate others. These they have no wish to destroy; they would much rather bring such civilizations to reason, or, failing that, outwit them. If attacked, the crew will defend itself, adapting equipment on the ship for temporary use as weapons.

1.13 Subjective Camera -- A method of teaching the manipulation of shapes and materials by shooting over the shoulder of a child working with his hands. The viewer develops a sense of empathy which can help

in depth perception as objects are organized on the screen. Besides being cheaper than animation, the trial and error shown in the process of putting something together may be clearer than "magic" (animated) assembly, and may help develop the ability to manipulate shapes mentally. Possible subjects include geometric shape blocks, tangrams, etc., manipulated on the plane and 3-D constructions such as Soma cubes or platonic solids with coffee stirrers or soda straws. This can be used to develop the concepts of point of view, translation and reflection of plane figures.

1.14 Time Machine -- An approach to historical aspects of math, this format could be presented in several ways. As science fiction, interesting bits could be developed where kids interact with the ancients to show that basic concepts such as place value which we take for granted were not known by great mathematicians of ancient times. Also, filmed sequences in costume without the sci-fi element could be used around something like building a pyramid. Another approach would be to use a faked computer display to address specific math history questions (e.g. how did they multiply at that time?) in sort of an instant reference library mode.

1.15 "Kid on the Street" -- A roving reporter (perhaps a real network news personality) asking kids questions about math. Skillful editing can make this bit a humorous and effective lead-in to specific content areas.

1.16 Senorita Meter Maid (nee Supermetric vs. Underfoot): -- Series depicting the weaknesses of the English system and the ease and

strength of the metric system. It would teach basic metric units and conversion between units, and show why we are moving to adopt it over foot system. Meter Maid, familiar with the metric system by virtue of background in Mexico, contends with Underfoot, staid old Englishman or American businessman with large feet, about such disadvantages as multiplication by 3, 12, etc.

1.17 Problems and Puzzles -- Short bits of various kinds of brain teasers presented in compelling and imaginative ways. End of show format: present a problem or puzzle before the credits, then run the credits and after the credits show the answer. Make use of that time for viewer activity.

1.18 Horror Show Techniques -- Quantitative concepts could be introduced into discussion of the impossibility of various typical horror show formats. For instance, a film clip of King Kong or Rodan could be interrupted with "that's impossible", explaining that animals that large could not function as depicted. One segment could expose the scaling "tricks" of dinosaur movies using tiny lizards photographically blown up. Another approach might use the classical monster characters (Dracula, et. al.) in comedy bits with math content.

1.19 The Right Brothers -- One brother is very careful and calculating and the other is quick and clever. The idea is to show two ways of coming up with the "right" answer, including the values of estimation where a perfectly accurate answer is not necessary. Various bits would show that both approaches have their place.

1.20 Big Numbers and Orders of Magnitude -- Using things that are familiar in large quantities to the audience, camera zoom or sequence of stills can show the powers of ten with bricks, grains of sand, holes in a screen, drops of water, etc. Smaller orders might be counted, with estimation brought in with larger numbers (whole building of bricks, block, city). Counting by tens, hundreds, etc. might be useful.

1.21 Bridging Material -- Short bits, to be used between longer formats. Various presentation styles for subject matter such as multiples counting, multiplication tables, shapes in the environment, etc. Addition facts, verbal operations with numbers, fractions (1/2, 3/6, 2/4, 4/8).

1.22 Old Serials -- Stock footage of old time cliffhanger serials, with new sound track dealing with math. Tongue-in-cheek, easy going dialogue (how far is the planet now?) while catastrophic scenes are going on (Flash Gordon spaceship crashing into planet).

1.23 "Rabbit Magician" -- A rabbit dressed as a magician (presumably live action with costume rather than animated) pulling humans out of a hat (video trickery here) and doing magical things with numbers, cards, and paper folding. Also variations or parodies of classical magic tricks (sawing man in thirds) can be used with math content.

1.24 "Why That Shape?" -- Bits which explore the shapes of objects in relation to physics and function. Soap bubbles, structural trusses, beehives, and snail shells are possible subjects.

1.25 Paper Folding -- Many geometric concepts can be easily demonstrated through paper folding. Projects such as paper airplanes and origami figures can be presented, perhaps by subjective camera technique.

1.26 "String Along" -- A piece of string is "pixilated" (hand animated). Useful for 2-D geometric, topological, or analytical ideas -- perimeter to area, topological equivalencies, different curves, braiding, knots, macrame, etc. String has reality; kids can duplicate shapes and changes.

1.27 Cultural Games and Puzzles -- Using different cultural settings to present indigenous games and other math processes. For instance, tangrams or chinese checker might be presented in a Chinese setting; "Oh wah ree" shown in African setting, etc.

1.28 "Comedy Carpenter" -- Combining the real math involved with carpentry and the slapstick tradition to get at measurement, fractions, convenient and appropriate units of measurement. A train can be measured by the number of cars. Why measure in standard units? This is not as obvious a question as it first seems. If you must communicate a relatively exact measurement, both parties must use identical units. This could be demonstrated in an entertaining way with a comedy skit: Sam Gram has a floor board missing. He

measures it with his arm and finds that he needs a piece of wood as long as the distance between his elbow and the end of his little finger. He calls up the lumberyard and gives this measurement. We see that the man at the yard is somewhat shorter than Sam, so when he gets his piece of wood it falls through the floor. Next, he measures it with Coke bottles, and tells the yard to make it two Coke bottles long. They use a king size bottle and he finds the board to be too long. At this point his young friend Peter Liter brings him a tape measure and he calls in the exact measurement to get a board that fits.

1.29 Comic Books -- Use popular comics characters (or parodies thereof) to deal with math content in an entertaining way.

1.30 Space and Undersea -- Advanced technologies are embedded with math content. These two are particularly interesting to target age, and can be presented in many ways, real to fantastic, to introduce more sophisticated math concepts.

NOTE: One of the small groups chose to assemble a complete, prototype half-hour show, thought of as the third show in the series and drawing upon some of the formats listed above. The group did not present this outline as an actual proposal for a show; rather, developing the show was one technique for examining some of the problems that arise in designing a program of this kind.

1.31 "Show Number Three"

:30 sec OPENING LOGO: animation

2:00 min THE RIGHT BROTHERS: live

One brother is at table with two large boxes of ping pong balls, a short cubical one and a tall, thin one. He is hard at work measuring the sides of the boxes (or perhaps counting the balls), when his brother comes in and asks what he's doing. When told that brother A wants to know which box holds the most, brother B pours out one box onto the floor, then pours the other box into the first, comparing the level of balls.

:30 sec ORDERS OF MAGNITUDE: animation

Camera zooms from one ping pong ball to ten, then one hundred and a thousand.

1:30 min "KID ON THE STREET": live

Reporter asks the question "What is a fraction?"

2:00 min "MAGIC RABBIT": live

Rabbit magician pulls man out of a hat, then proceeds to saw him in thirds. Rhythm of sawing accompanied by multilingual counting to three.

1:00 min BRIDGING MATERIAL: live

Latin American folk dance and music in 3/4 time.

3:00 min "THE CLUB": live

New member is being initiated into the club. His "test" is to find clubhouse using a special map drawn by members. There are shots of kid with map on the street, as gang waits in clubhouse talking about the extreme difficulty of the problem. Such difficulties as metric measurements are in the map. New member uses a heuristic in finding the clubhouse, as he appears with the leader's sister, who has come to remind him of something. Segment is cut on a note of unresolve, as to be continued.

:10 sec BRIDGING MATERIAL: live

Football center counting by squares (1,4,9, etc.); when ball is hiked it turns out to be cubical.

1:00 min "STRING ALONG": animation (pixilation)

String continuously deforms itself into various geometric shapes: straight line, square, triangle, etc.

5:00 min "STRAIGHT ARROW": live

Introduction having been accomplished in earlier show, a Native American and his family are building a shelter out of natural materials. He speaks of tipis and other traditional shelters as this one is being built, and about structural considerations in putting together a lean-to.

:45 sec ORDERS OF MAGNITUDE: live (perhaps with superimposed animation)

Camera starts with one brick, then ten, then hundred, etc. At some point wall is not adequate for number, and building is shown, then perhaps a whole block of brick buildings.

3:00 min "METER MAID AND UNDERFOOT": live

Senorita Meter Maid and Henry Underfoot find examples of conversion of measuring units. Underfoot is shown to have to do much computation while Meter Maid can do them all in her head.

2:30 min CULTURAL MATERIAL: live and animation

The geometry of weaving. Brief discussion of weaving process in Native American culture, and montage of various tribal weaving styles, along with environmental shots for each example. The patterns bear some relationship to the environment; that is, tribes in desert and plains areas use geometric patterns which use straight lines and stark geometry, while those in forested areas tend toward more organic and complex patterns.

5:00 min "THE CLUB" Continued: live

There is some discussion as to whether new member "cheated" by using heuristic in finding clubhouse. New kid maintains that he could have finished using map, but that it was much faster to follow the leader's sister.

He then suggests that he teach the club an African game, "Oh Wah Ree", which is played with an egg carton and pebbles. This convinces the group to accept him in the club, and they learn to play the game.

1:00 min CREDITS: animation

SECTION TWO

MISCELLANEOUS

2.1 Symmetry: the body having pairs; right and left; mirror image and shapes that are the same shape reflected.

2.2 Shapes: crystalline -- natural -- man-made; the world isn't as complicated as it looks (very few basic shapes) shapes in urban setting -- circle montage (manhole cover, etc.) square -- sidewalk, window; stack of pennies cylinder. Math ties things together -- power to put the world in order.

2.3 Spatial Equipartition in art: Film of regular patterning in architecture (tiles, etc.) and in artworks such as those of M.C. Escher. If subjects are divided into classes, perhaps some rules may be introduced even to the principles of crystal lattices.

2.4 3-D Close-packing; Science fiction might be an effective style for an exploration of solids which close-pack other than the cube. Multi-unit dwellings formed of truncated octahedrons might be shown in outer space, with the idea presented that such structuring is an economical equipartition of space.

Another approach to this same idea would be an analysis of the structure of foam, in much the same way that a beehive shows the same principle for the hexagon.

2.5 Paper doll cutting: symmetry of folding and cutting.

2.6 Ghana -- pottery by walking around it, as opposed to wheel turning with pot.

2.7 Operations with numbers should be shown to operate in both directions -- taking numbers apart and putting them together, showing the logic and commutativity of the number system.

2.8 Concerns of kids: identity -- who am I, etc.; connectness -- where do I fit in, etc.; power -- what can I do, etc.; money; food; bodies; space travel; music; clothes; television; sex; funny stuff; rules -- parents, teachers, police; school -- good, bad; sports, games; strength, beauty; what will/can I be when I grow up? where I/others live; tricking people, helping people; extremes; bad streets, good neighborhoods; race relations; crime; friendship.

2.9 The importance of kids communicating with the show: postcards distributed through the schools?

2.10 Building with old newspapers: 1000 things to do with with newspapers without reading them.

2.11 Board games and paper games: these being physically made, played, and discussed as a regular feature. (See Board and Table Games from Many Civilizations, R.C. Bell, Vol. 1 & 2, 2nd ed. 1969.)

2.12 Games: games using numbers from license plates.

2.13 Games: tangrams and some cube puzzles easy to make.

2.14 Games: development of cheap games -- use a deck of playing cards to build things. Notch them or cut them up in smaller shapes for construction.

2.15 Deck of cards to transfer shape of object to paper or model: Concave-Convex form of shape at ends of card deck.

2.16 Space: perceived space (things closer seem larger); felt space (sitting next to someone you know in the subway vs. someone you don't know).

2.17 Two kinds of strategy: make evident the math in one's own life, and also teach new experiences and concepts. Make the strange familiar as well as the familiar strange.

2.18 Mathematics as a description of reality: Measurement, mapping, counting things in the evnironment.

2.19 How many languages? How many different kinds of languages? Languages which no one can speak or read?

2.20 None of the math concepts are discrete -- all are interrelated. If we take human problems with a wide range of applicability, we can fit content to them. Within each program, we should have some reference to the value question. Number concepts provide insight into what happens, but not into what ought to happen.

2.21 Heuristics: Apply problem solving techniques to examples from standard tests.

2.22 Tests: Examples of kinds of problems given on various tests (IQ, etc.). How do you take a test to do the best with what you know? Teach kids to be "test-wise."

2.23 Problem solving: show several different ways of solving specific problem: i.e., 15 x 7, one kid makes lattice with markers, another goes to store and looks at calculators, another uses algorithm, etc.

2.24 Origami, by the dawn's early light: Betsy Ross is sewing. George Washington comes in with a large piece of cloth on which is drawn the design of the American flag, with stars that are quite irregular. Betsy takes a strip of cloth and ties a flattened knot, and folds over one end. When viewed through the window, George sees this as a perfect 5-pointed star. Betsy then uses it to construct a star out of cardboard for making cloth stars for the flag. An unidentified general comes in and tells George excitedly about his idea for an officer's quarters across the Potomac with five sides. George dismisses the idea as un-American.

2.25 Compass and straightedge: Geometric construction can lead to impressive geometric designs from students whose representational drawings are an embarrassment to them. A substantial program of animated and live action demonstrations should be developed and augmented with hands-on materials.

2.26 Backgrounds: many ingenious devices in the films of Red Grooms and Red Ball Workshop; urban settings are loosely drawn and props of paper mache are caricatures of the objects represented. The film techniques use a lot of pixilation, with actors bizarrely costumed in the same style as the set. Advantages are lower cost than animation and wildly comical effects, which easily make use of kids as actors and designers.

2.27 Believe it or not: Amazing historical facts involving quantity.

2.28 Conic sections from projections from flashlight, lampshade to wall and ceiling.

2.29 The cardinal element of all Native American culture is the harmonious relationship between man and nature. Nature is the most elegant mathematician, with structures and ecological balances we are just beginning to discover. The ecological viewpoint and its quantitative aspects are vital educational goals today.

2.30 We want the kids to want to learn new things because they will gain real power, and the power gives them the freedom to do things.

2.31 How do you indicate to kids which concepts are important? Is it enough to repeat them more?

2.32 Should the show take up the question of unseen money? Devaluation, cost of living?

2.33 Unseen theft -- not just taking, but also not giving.

2.34 Math has traditionally been taught in an abstract way; the TV screen gives us the opportunity to tie math to something real.

2.34 What would do for $1.00? Rake a lawn, carry bundles, beat someone up?(values).

2.36 Program should combine the cognitive with the affective -- we can get some clues from confluent education.

2.37 Reduce the numbering system objectives; work the objectives into the other four areas.

2.38 Animals -- sizes, shapes, and weight; structural constraints. Why are there no six-foot-long insects? Why is it that most fleas, most people, and most elephants can all jump up about three feet? Techniques of locomotion; fractions of time spent eating; flying, leaping, gliding, and mobility.

2.39 Around the World in 80 Days: many different modes of transportation; time, speed, and distance. Navigation; finding one's position under a variety of local conditions. Mapping; time zones. Assessing alternatives on a quantitative basis.

2.40 Astronomy: Some very large numbers. Angles as data. Relative size -- Is the sun big or small? Apparent brightness versus distance. How do the big telescopes work? -- a shaving-mirror version. Why and how must a telescope move during a prolonged observation?

2.41 Athletics -- How high? How far? How fast? Center of gravity; resonant motion; trajectory. Acceleration, speed, stamina, and energy. Why do pole-vaulters prefer fiberglass to bamboo? What makes a curve ball curve? Friction and momentum in curling. Physics of sky-diving; controlling speed and "position."

2.42 Balloon: Suppose you are in one, in a dense fog. How might you find your location? Your altitude? Whether it is safe to descend? What keeps you from falling? How do you control altitude and direction?

2.43 Billiards: geometry on a pool table.

2.44 Cards and Dice: probability applied; games of mathematical inference.

2.45 Chess

2.46 Kites

2.47 Mathamatical games: of all sorts, including Monopoly, Battleship, map games, and number games; puzzles.

2.48 Movies: Teach a few simple computer commands that permit the design of computer-animated movies. Viewers can send in for details, and can submit their own "programs" for films. The best one will be produced and shown on television.

2.49 Music and Instruments: physics and esthetics. Rounds, canons, and fugues. Mathematics of the scale. Making simple instruments.

2.50 Origami: The mathematics and esthetics of paper-folding.

2.51 Paper airplanes: geometry and aerodynamics. Why do small paper planes generally fly better than large ones?

2.52 Spaceflight: ballistics; trajectories; orbits. Mathematics of putting a man on the moon. Planetary probes, speed-of-light problems in telemetry and control.

2.53 Spies: mathematical codes; infrared photography; parabolic microphones; miniaturization of data and equipment; identification and communication. Many game possibilities.

2.54 Submarines: inertial navigation. What does a group of people need in order to live for a month underwater? Are underwater cities practical? Bouyancy and control of depth.

2.55 Swiss Family Robinson: Suppose a family were stranded in a benign environment, equipped with certain tools and supplies. How would they explore? What would they look for? What could they build and do to improve their lot?

2.56 Utopia: Imagine a culture in which everyone devotes himself to the arts of his choice, with modern technology available. In what sorts of activities might people engage? Which of these have quantitative components?

SECTION THREE

DECIMAL NUMBER SYSTEM

3.1 Numbers: help kids to read numbers. Emphasize decade boundaries and numbers which have similar digits. Methods of presenting verbalizations might be combined with other content areas, i.e., place value.

3.2 Numbers: contemporary art is replete with works having numerals as the subject. Jasper Johns and Robert Indiana, both in their own styles, have created quite a large body of work which would make a striking film. It could be used as "logo" sequence for program sections pertaining to counting. A separate small film for each integer could be made, compiling practical and symbolic attributes, and including appropriate artworks.

3.3 Numbers: House numbers -- has direction, odd and even -- blocks of 100? The phone book -- how many pages, how many names? Pennies or dimes on table -- how many, how much?

3.4 Number patterns: number sequences with various patterns -- show derivations and graphic qualities of Fibonacci series, square numbers, triangular numbers, factorials, etc.

3.5 Verbal manipulations of numbers: as a puzzle 'take 3 add 5 subtract 4 multiply by 2 . . .' might work well in some game situations.

3.6 Think of a number.
Double it.
Add 10.
Divide by 2.
Subtract the number you started with.
Your answer is 5.
(many other possible variations)

3.7 Zero: power of zero as digit; invention of zero in India; important use of zero by arabic cultures; introduction of arabic numerals into European culture.

3.8 Zero and one: The special qualities of 0 and 1 are a source of confusion to kids. The relatively few basic facts about operations with these digits might be best taught with a mnemonic or rote method. Power of ten notation and the transition from positive to negative powers is difficult even for adults to conceptualize but the necessary number of examples for a working knowledge of the system is small. Several frameworks for presenting 0 and 1 operations are needed.

3.9 Symbols: clever ways should be developed to introduce math symbols. Besides most common operations, symbols such as equals, approximately equals, greater than, less than, etc., are logical in their graphic form and can be presented in a similar way to Sesame Street's letters and numbers and Electric Company's punctation bits.

3.10 Multiplication: rote methods must be developed which contain some element of fun -- funny song, song being sung by famous person, etc.

3.11 Counting: Counting by multiples as key to multiplication table. Use graphic and/or musical devices to make numbers easy to see and remember -- parade, rows of n people marching by, etc.

3.12 Counting sheep: in order to speed up process of getting to sleep, kid begins counting them by twos, threes, etc.

3.13 The use of animation was discussed in terms of presenting the concept of place value, taking a number and displaying its components underneath. The "left-to-right" algorithms for addition and multiplication (not commonly used -- most run right to left) were also seen to demonstrate the place value concept. There was some difficulty, however, in devising a graphic or manual form for counting which was perfectly clear as to the concept. That is, a group of kids counting on fingers, with one kid counting ones, another tens, another hundreds, do not make a perfect graphic analog of the decimal system, as "10" is represented by ten fingers on the "ones" kid and one finger on the "tens" kid. This is fine for counting, but integer notation has no such duplication of whole numbers: The nine integers and the zero are not analogous to the ten positive digits of the hand. In the same way, a ten-by-ten grid is an imperfect way of graphically illustrating place value notation in counting from one to one hundred -- the first integer of the new decade (10, 20, etc.) falls on the right hand side, on a separate line from the rest of that decade. Perhaps a gigantic model of a hand calculator, sequentially displaying the integers as an n+1 addition operation might be the most honest description of the basics of the notation. It seems important to find a graphically clear analog to base ten counting in order to develop a solid understanding of place value and its function in the operative algorithms.

3.14 Place value: degrees of correctness in simple arithmetic -- show the value of approximation by distinguishing between errors on the left side of figures and errors on the right. If the correct answer is 8888, 8887 is much more correct than 7888. Algorithms which work from left to right should reinforce the concept.

3.15 Decimal system: Doris (nee Dewey) Decimal strikes again, moving into the wrong place and causing great confusion. "What? A dollar for a piece of bubble gum?" "A $1,000,000.00 income tax?" Doris Decimal positive role -- 10 kids with $6.15 to divide; how? How many leaves -- 10 on each branch. A parade, 10 abreast -- every 10 10s there is a drummer. Swimming pool, hands over edge; child counts fingers, divides by 10.

3.16 Cardinal numbers, orders of magnitude, estimation: Either in zoom or sequence of stills show 1 object, 10, 100, . . . Bricks, drops of water, grains of sand, with obvious estimation used in higher orders.

3.17 Place value counting: verbal counting of numbers which are combinations of one digit, i.e. 8, 88, 888, 8888, ... The numbers appear on the screen calculator style and kids try to say each succeeding number, with increasing difficulty. Mistakes in higher numbers could be taken for comic effect. The atmosphere should be pure fun.

3.18 Square grid: showing numbers squared by montage.

3.19 Square as theme: geometry of square, square numbers, square roots, square dancing, diagonal irrational quantity, use of carpenter's square, relationship to other quadrilaterals.

3.20 Measure diagonals of rectangles: not exactly measurable -- irrational numbers.

3.21 Tessellations: 2-D tile patterns; how to draw regular patterns, how to generate irregular ones. 3-D tessellations: cubes and other close packing solids. Everyday tessellations: Film montage of tile floors, skyscraper windows, nets, chain link fences, etc.

3.22 Powers of two: Doubling things. What happens when paper is folded repeatedly? What is a chain reaction? How often does an amoeba or an egg cell split, how many will there be after a day or a week?

3.23 Infinity: a difficult concept, but an exciting and important one. Can it be presented for fun without being a source of confusion? Can kids be made to feel comfortable that they can't understand something? Perhaps it can be shown that infinity is in some sense not understandable by anyone.

3.24 Fractions: Use concept of "fracture" -- the number of things an object is broken into is the denominator, the number of pieces which are taken is the numerator. Rationalizing fractions then becomes a concrete task -- breaking spaghetti or whatever until denominators match, then counting pieces taken.

3.25 Music: Rhythm measured by use of division and fractions.

3.26 Division: "How many sheep in your flock?" "Well, let's see . . . 197." "How did you count them so fast?" "It was easy -- I just counted the legs and divided by four."

3.27 Decimal fractions: Focus on the use of decimals in supermarkets. What is a unit price? How can it be used to compare sale prices and such?

3.28 Fractions: montage on a quarter -- quarter note, 25¢, quartet, quarterback.

3.29 Buying something at a fraction of the original cost -- what fraction? Suggests super hype voice track of commercials, then questioning voice and figuring of fractions.

3.30 Arithmetricks: short cuts for computation.

3.31 Tricks for checking results of computation.

3.32 Eating out: Tipping, taxes, adding up the bill.

3.33 Discount: season tickets, round trip tickets, 20¢ each or 2 for 35¢.

3.34 State Lottery: lump sum vs. lifetime income contests -- grandmother and grandson.

3.35 Counting and ordering: The origins of modern school arithmetic. The algorithms are not so new nor so useful as claimed. The pre-Renaissance counting board, African ways of reckoning, Chinese and Japanese abacuses, etc. would build up into a good context for algorithm drill, which might be thought out afresh while one is at it.

3.36 How to generate log scale: successive approximation, making slide rule starting with 2 x 2 = 4, later guessing at 1.5, 3 and testing multiplication. Another way: draw log spiral and extend parallel lines from intersections on line.

3.37 Math troubleshooting: "bubble, bubble, toil and trouble" attractive witch answers questions from target population about math troubles.

3.38 Time machine: historical sketches of early number systems to establish advantages of place value and algorithms.

3.39 Time machine: Roman addition and subtraction (Scientific American, Dec.) Their notation and calculation procedures were separate. Why is our system better?

3.40 Baseball: statistics in baseball; what is batting average? What is the record of strike outs, home runs? Mention Hank Aaron's bid for HR record.

3.41 Harlem Globetrotters: Popping in baskets one after another, score-counting by 2's; mapping zones and plays; rhythm of ball dribbles.

3.42 Game: Two kids alternately choosing numbers between 1 and 5 (or using some random sequence) to see who can reach 31 first -- how soon can they predict the winner? Cooperation vs. competition.

3.43 Random numbers, counting on a geiger counter: Counting cosmic rays on a geiger counter with games which emphasize the unpredictability of random physical processes. Musical chairs, recording the seconds between clicks, guessing when the next click will come. Physics and math can be woven into script.

3.44 Multiplication tables through songs or rhythmic chants.

3.45 Simple, inexpensive slide rules for addition/subtraction and multiplication/division.

3.46 Multiplication via counting of rectangular arrays; also demonstrates commutativity of multiplication (3 x 4 = 4 x 3).

SECTION FOUR

MEASUREMENT

4.1 Establishing the necessity of measurement, and of consistent units, through humorous skits.

4.2 Film footage of surveyors, pharmacists, scales that measure the weight of loaded trucks, meteorologists, grocers, athletes and coaches, chefs, tailors, people who lay carpets and floor tiles, carpenters, plumbers, physicians and nurses, ...

4.3 Measurements over many different orders of magnitude; e.g., one could measure the distance to the moon in millimeters, or the "weight" of the earth in grams.

4.4 Measurement: The garbage bag -- pounds of garbage in your household (per day, week). What is the volume, is it compacted, is that good? Garbageman as hero -- how is garbage processed, where does it go? What are some unique answers to solid waste problem?

4.5 Time: How long do things take? Organize your time. Using time as quantitative factor in planning and reasoning.

4.6 Measurement: bushel of lettuce vs. bushel of cherries.

4.7 Measurement, estimation: African and Asian women who make clothes without pattern -- measure by string and by touch -- need standardized measures for giving dimensions via telephone.

4.8 Measurement: human hand as weighing scale -- picking up 10 pennies without counting; fruit and vegetable vender accurately estimating four pounds of apples, etc.

4.9 How fast? Examples of extremes of fast and slow -- how can speed be expressed? Miles per hour might be a good starting point but shown to be inappropriate for extremes.

4.10 What is a fire hydrant? What is the difference in water flow rates with hydrant open and sprinkler head?

4.11 Measuring: Cooking; recipes of many groups should be made a la Julia Child, with free commentary. Numbers, measures, etc., could be done as a gloss -- voice over -- or titles, even where the actual cooks didn't do it. Some cooks could be kids; some, people in their own diverse homes.

4.12 How much feed does it take to make a quart of milk? How much grass or grain of what quality does it take to bring a steer to market? Grain prices affect meat prices. What else affects meat prices? What is the quantitative efficiency of a cow or steer?

4.13 Soap bubble: why is it that shape? maximum volume, minimum surface area. Why no cube balloons?

4.14 Weight lifting: world record. How much weight -- grocery bags, luggage, bushels of various fruits and vegetables (grocery boys, porters, farm workers). How much can boy, man, fork lift, crane, etc., lift?

4.15 The Guinness Book of Records: Present the world records of various things, some comical; all involve quantities and rates.

4.16 Measurement: track and field -- starting points at different places to allow for same distance to finish line. Jumping and vaulting.

4.17 Sports: Explore the structure and design of all kinds of balls used in all kinds of sports. Weight, size, the importance of seams in baseball, patterns of balls laid out flat, i.e. soccer ball is a dodecahedron projected onto a sphere. Distances involved in different sports and balls, i.e. how long is a home run, field goal, etc., in various ball parks.

4.18 Metric system: Present sporting events in exciting ways, using metric system for track, swimming, weights, etc.

4.19 Measuring creatures: Imaginary animals spotted in units of measurement, seeing the world in terms of their particular units. Centimeter creature arguing with meter creature. The world as seen through the eyes of each.

4.20 Metric system: Millimeter worm and centimeter worm; "millie worm" (like inch worm)

4.21 Metric system: Assign characters to prefixes as mnemonic so that kids can remember their order, i.e. Micro Virus, Milli Mosquito, Centi Cat, Deci Dog, Kilo Kangaroo, Mega Monster.

4.22 Thunder and lightning: time to distance; speed of sound.

4.23 Phases of moon -- 28 day cycle. Why do we only see one side? Why do calendars use 1st quarter, last quarter, new moon, full moon, but not half moon? Why does the moon seem larger on the horizon?

Details of cycle as in African Science booklet.

4.24 Calendars: History of calendars -- lunar months, stellar calendars, Stonehenge, sundials over year, solstices, equinoxes, etc.

4.25 Mail: How many pounds a year? How do zip codes work? History of transportation times for mail. How many stamps on a sheet, how much money?

4.26 Describing the world: Metric system and monster -- kid astronauts describing their world to space monster who makes replicas -- usually with some comic distortion having to do with improper metric units. A child's voice explaining metric system and simple geometric concepts to a rather stupid monster might help to detoxify the decimal system.

SECTION FIVE

ESTIMATION

5.1 Introduction of the prefixes mega, kilo, milli, and micro to facilitate estimates of large and small quantities. ("There are about 2 megapeople in the Boston area, and about 200 megapeople in the United States.")

5.2 Inappropriate units to humorous effect: "I am writing on 10 micro-acres of paper."

5.3 Estimates that require still other estimates: "How many supermarkets are there in the United States?" (How many people shop at each supermarket?)

5.4 "Ridiculous" problems: How many bedbugs in the city of Chicago?

5.5 Film footage of people who use estimation in their work; e.g. bartender pouring ingredients into a shaker "by eye," then emptying the shaker by filling a glass exactly to its brim.

5.6 Estimation: Estimates of many things; leaves in a pile, feathers in a bird, leaves on a tree; volume or weight.

5.7 Estimation in human coordination: We should foster the remarkable human skills.

5.8 Estimation: life and death examples -- trapeze artists, Evel Knievel motorcycle jumps, skydivers.

5.9 Estimation: In Acapulco men dive 100 feet into 12 feet of water. They must estimate how long it will take them to descend and how long the wave will take to raise the water level enough for the dive.

5.10 Estimation: Concept (and perhaps symbols) of greater than and less than in dealing with estimation.

5.11 Estimation: Estimating the weather -- what does % probability of rain mean? How does Farmer's Almanac estimate weather over whole year? How accurate are they?

5.12 Estimation: Quiz show, Which is Bigger? Aircraft carrier or football field?

5.13 Estimation: Estimating age and weight; men who work carnival guessing ages and weight.

5.14 Estimation: Halftone dots on newspaper photographs and Ben Day color dots used to print Sunday comic strips -- how many? How would the pictures look with fewer dots? How many lines on the television screen? How many "dots" can be represented on each line? How is this affected by the quality of reception? Why are pictures clearer in the movies than on television?

SECTION SIX

MAPPING AND SCALING

6.1 Contour maps; e.g., a contour map of a person's face.

6.2 Floor plans and elevations (side views) of houses, apartment buildings, and schools.

6.3 Satellite photographs compared with world maps and globes; curvature of the earth.

6.4 Navigation in a jet airliner.

6.5 Maps of the same scene, but to drastically different scales: from floor plan to diagram of solar system in about 12 stages.

6.6 Relationships between an aerial photograph (or the view from a tall building) and a city map.

6.7 Air photos: Think of a map of the USA. Enclose a small square somewhere, zoom in, and cut to an air photo. Then cut to a live action shot with someone there, pointing at the shore, river, mountain, famous place, whatever. Scale could be strongly brought in, but whole thing can be used for real locations. Homes of well known people from every group, historical events, simple ways of making a living, etc. How about the farms in Canyon de Chelly, a schoolroom on a Georgia Sea Island (Gullah speech and music), the Watts Tower, whatever. Done fast, this allows geographical-historical-social material to complement the rest of show, still within the very useful context of maps and their meaning.

6.8 Mapping: Which is a cliff? Which is a half cliff, which a hill? How do you tell from a contour map? Are there any overhanging cliffs? How do they look on a map? Why are they so rare?

6.9 City maps: Heavy use of street maps for kids solving mapping problems. Investigate use of wax paper for tracing routes.

6.10 Traffic on one-way streets: Why and when do one-way streets make it faster and safer for cars to move through the city? How do you design a system of streets in a city, real or imaginary? What is traffic control and who does it now?

6.11 Mapping: Bring kids to a new city and see them try to find their way around. A way to explain grid patterns of some cities (Chicago) which are very logical, and mention others (Boston) which have no overall pattern. Tricks for finding your way around using maps. In the absence of map which has street nos., call bus information with street number of where you want to go, ask for cross street, and find on street map.

6.12 How far is it to school? Walking? In a car? Are there shortcuts a car can't take? How much time does it take both ways. Assuming the car is faster, does the shorter distance of walking make up the difference?

6.13 Map of utility delivery systems: Water, electricity, gas, telephone, alarms, streetlights, sewage, storm drains. Process of tearing up street to repair systems, need for maps in digging. Subway maps.

6.14 Mapping: The Neighborhood. Hand-held camera following kid home from school, aerial view showing entire scene; grid map showing location of home, school, grocery store, aunt's house, subway and bus lines. Various problems: what's the quickest way home from school, etc. What's the safest way? (add dangerous blocks;) what's the scenic route? If you could reshape the neighborhood, how would you plan it? Parks and industry, advantages and disadvantages?

6.15 Mapping: A simple airport with radar scope lead in to air traffic controller job in real airport.

6.16 Navigation: Navigating a plane using geometry; orientation of free space; navigation involved in getting a satellite into orbit.

6.17 Mapping: Piloting an airplane -- navigational concerns, angles of ascent and descent, angles of banking turns, etc.

6.18 Mapping: How many miles does a police car travel in a year? What route on 'beat'? Routes for delivery trucks -- most stops, least distance -- other efficient routes for group of shopping errands, bus lines, utility networks, etc.

6.19 Mapping: Mapping a supermarket according to products -- one way aisles, shopping strategies, i.e. shortest path for a few specific items.

6.20 Maps: Costumed pirate entering Pittsburg with treasure map. Shots of him downtown, pacing off with map. Finally shots of him in dark, large building. He paces off final instructions, camera zooms back to show that he is in the dugout of Pirates. He asks them about a job.

6.21 Human body: Blood, nerves, lymphatic systems as maps; heartbeat, pulse -- electrocardiograph; electroencephalograph; blood pressure; skeletal structure; opposition principle of muscles; sympathetic and parasympathetic nervous systems; brain as computer; mapping of human beings; hair on head, whorl; pacemaker.

6.22 Exploring human scale: Age and size, architecture and human scale; furniture and utensils; weight; measuring arm span vs. height. Changes in body proportions (as well as size) as a person grows up from infancy to adulthood.

6.23 Carpenter "squaring" door frame: measuring diagonals to see if they are equal, hence, "square".

6.24 Point of view: Show kids working together to describe a building or something they all saw from a different view -- see if together they can build a model of actual building. Use "elephant box" (cardboard box with tracing paper over holes in 3 sides); shine flashlight through object casting shadow on tracing paper. Top view and 2 side views should give enough information for kids to build plasticine model or to guess what it is.

6.25 Making boxes: How to draw a pattern for cube or rectangular solid; plans for regular polyhedra.

6.26 Relativity: Some people may appear to be 10 feet tall; short/long pants -- several people can be right in judging size, depending on their own size in relation to the object.

6.27 Scaling things: A coin and a facsimile cubed. The change of size but not of form -- a ruler, and one 10 times bigger. A coin 10 times size -- 100, 1000 times weight? How many times cost? Graph different properties in scaling -- length, volume, weight, etc.

6.28 Scale: The world as seen from the eye of a mouse, Japanses beetle, gnat, elephant -- comical situations as a result; descriptions of the same thing from different points of view (there are fables which use this).

6.29 Size constancy: Streetlights look small but are quite large. Other objects with which we are more familiar look the right size at a distance, but we never see street lights close up so they seem smaller than they are. What else?

6.30 The Golden Section and Logarithmic Spiral: Computer and conventional animation can show the construction of a golden section rectangle and a logarithmic spiral within it. The film should then explore its growth function in plant and animal life. Difficult to organize to promote cognition, but potentially inspiring.

6.31 Rectangular proportions: Common rectangular objects compared in the same scale to show differing proportions. May lead into geometry of root n rectangles, concept of ratio by measurement of sides and scaling down to 1: n, or how an artwork is affected by a change in its border.

6.32 Da Vinci Scenarios: As a central figure in the Renaissance associated with art, science, and technology, Leonardo might serve as an appropriate medium for a number of mathematical processes developed in his time. In the examples below, farcical elements are presented to provide both entertainment and "extra" information. (The Apprentice, by his blunders, may bring out sidelights of the main topic, as in the case of mapping grids which distort the original.) These sketches are conceived as silent (non-verbal) live action film sequences, but a series of them might be better suited to cel animation, with or without dialogue, or to a straightforward treatment without comedy.

6.33 I Enlargement Grid: Apprentice is painting a billboard sized copy of the Mona Lisa under advertising copy (Pizzeria Mona Lisa, or something). The larger portrait is completely out of proportion, bearing little structural resemblance to the original. Leonardo enters and begins to gesture wildly upon seeing the billboard. Cut to same billboard with face whited out. Leonardo is using string to put a square grid over the original portrait. He then counts the squares, gesturing to the billboard as instruction to

to Apprentice for proportional enlargement. Cut to Apprentice completing new portrait on a grid which is composed of rectangles, so that it is distorted in a regular way. Leonardo enters, goes into a fit of rage, then looks at his wristwatch (perhaps a small hourglass) and spends a moment in agonized thought. He then goes to billboard and tilts it so that distortion is compensated for camera view.

6.35 Perspective: Besides a Leonardo vignette and experimentation with window transparencies, there are many optical illusions which should prove fascinating as an illustration of the importance of scaling to vision. A film about a photographer taking a number of pictures of a building which look different by virtue of changing film plane (with view camera) might help to establish the concept of the picture plane.

6.36 Pantograph: The construction of a simple pantograph will allow one to perform many scaling operations.

6.37 Film -- Graphic Artist at Work: The artist starts with a sketch which is done a specific size and shape. He then lays out a rectangle that same size and draws an extended diagonal. With a t-square and triangle, he draws horizontal and vertical lines which intersect at the diagonal. He then does a final drawing within the larger rectangle. (It will have been explained that the blue pencil he is using for the original rectangle and the diagonal is "invisible" to the camera which will photograph the final drawing.) After

the drawing is complete, he measures the enlarged outside dimension and takes a proportion wheel, aligning the original dimension with the enlarged one on the two scales. He then reads the percentage figure from the wheel and writes it down. He brings the drawing to the stat camera and puts it in the copy board; then sets the percentage scale to match what he has written down. When the photograph is processed it will be shown to be the same size as the original sketch.

6.38 Games with graph paper: Drawing an animal using plotted points or copying grid; scaling, 1/2 size, double size; comical distortions by changing grid for width or height. Maps; coded maps or pictures -- for 'secrets', pass on list of coordinate points instead of original map. Scaling -- scale drawing of mouse and elephant together; scale appropriate for one not for other.

6.39 Paper airplanes: The relationships of size to physical world -- what is the best size for paper airplane of particular design?

6.40 Point of view: Looking at objects in sequences of different points of view, exploring geometry of such things as buildings, stacks of oranges, mountains. Concepts of mapping and scale drawings can be introduced.

6.41 Point of view: Four kids watching the same event from different points of view, perhaps from each corner of a block or field, with walkie talkies.

6.42 Point of view: Wrecking crane -- from the side the ball seems to be hitting, from above it's nowhere near it.

SECTION SEVEN

GRAPHING

7.1 Heights of plants or people against time.

7.2 Population growth in graphical form, with extrapolations.

7.3 Film footage of a flat-bed plotter (drawing something interesting) to illustrate rectangular coordinates in two dimensions.

7.4 An overhead traveling crane (also called a bridge crane; the type often seen in scrapyards): rectangular coordinates in two and three dimensions.

7.5 A modern Swedish-type construction crane: polar coordinates in two dimensions and cylindrical coordinates in three dimensions.

7.6 A conventional mobile crane: modified spherical coordinates.

7.7 Lines of latitude and longitude: spherical coordinates.

7.8 The work of an aircraft controller: locating airplanes in a coordinate system -- a life-and-death application of graphing principles.

7.9 Hypothetical cities (or real ones, if there are clean examples) laid out in rectangular and polar grids.

7.10 Temperature against time. (This example has an interesting property. A plot that shows an entire year of temperatures

for, say, Boston, will look like a thick, irregular line cycling through the seasons. But if one zooms in to examine a small portion in detail, there appear smaller cycles corresponding to individual days.)

7.11 Temperature against distance: Variation in temperature at a particular time in winter, along a line running from Bangor, Maine to San Diego, California.

7.12 Graphing music with an ocilloscope. Moog synthesizer -- making music with electronic graphs. White noise (waterfall). Noise and decibels; logarithmic scale of decibels and mechanics of the ear.

7.13 Music: Use oscilloscope with percussion instruments so graphic pattern is easy to see.

7.14 Music: Notes, different renditions by changing instruments and time of notes. Staff as graph -- have kids play hopscotch on a large staff and write their own songs.

7.15 Music: Develop catchy songs for basic math drudgery -- it will be easy for kids to remember words. Graph a melody (music notation is already a kind of graph). Compare standard notation with graph of pitch against time. Compare time signatures in graph form. Counterpoint and harmony -- rounds, superimposing same graph and listening. Explain concept of octaves and physics of string and reed instruments. Waterglass, xylophone. Other instruments easily made. Ethnic melodies. Melody as communication. Tell someone a melody. Voice as instrument.

7.16 Graphing: Inflation -- how many kids did a mother send to buy ice cream cones with 50¢ ? 1927 -- 4 kids, 1936 -- 3 kids, 1955 -- 2 kids, 1974 -- 1 kid. They stand by the wall (in costume) -- a graph.

7.17 Quantitative efficiency of machines: how much fuel -- how much work? Rates of fuel consumption/work output; cars -- miles per gallon, what speed? How heavy? Basic energy conversion.

7.18 Falling in parachutes -- graphing velocity against time. Terminal velocity affected by mass/size and shape. How high off the ground do you have to open the parachute to avoid injury? Show the fall at intervals of time, then animate to show vertical graph of fall with lines of time. Then rotate lines, separating line segments which have different lengths according to distance traveled in unit time. Graph now has equal time units and different segments of vertical distance.

7.19 Graphing: Roller coaster as graph. Other rides at carnival as graph possibilities.

7.20 Baseball outfielder: Goes on a collision course with baseball -- doesn't look at ball while running.

7.21 Sailing: If the other boat is stable in terms of point of reference, you're on a collision course.

7.22 Graphing: Divers and acrobats; graphing progress of fancy dives and acrobatics using slow motion and animated overlay.

7.23 Graphing: Drop-to-glide ratio of gliders. Combine with kids testing paper airplanes and graphing the results, estimating and 'straightening' curved distances. Use rubber band catapult for standardized initial thrust.

7.24 Graphing: Of one's own future -- chart one's life for the next six months. Money needed to buy a bicycle.

7.25 Polar coordinates: Games which involve mapping a set of points from a central point, such as radar scope -- airport game. Advantages include two clearly defined axes -- direction from center (360° or 1-12 o'clock) and distance from center. Rectangular coordinates are sometimes confusing to kids (which number comes first?). Circular temporal graphs (such as day-long temperature charts) might be shown.

7.26 Dot paper: As a form of graph paper, it is a good material for working integral problems in graphing and coordinate systems. Because only the points are represented, dot paper might be less confusing when whole number sets of coordinate points are sought by a kid.

7.27 Graphing: Stack playing cards over the edge of table. How high, how much cantilever before the stack falls. Graph the position of the cards, i.e. 1/2 + 1/4 + 1/6 + 1/8 etc.

7.28 Neon signs: News strip signs programmed by paper tape; relation to music box.

7.29 Graphing: Kid does push-ups every day (perhaps with older brother) and graphs his progress in the number of push-ups he can do over time.

7.30 Graphing: Typewriter as a coordinate system. Can recognizable drawings and shapes be communicated as instructions for a typewriter? Should instructions be in the form of a list, or map? i.e. 1st line x5x5x2x1x2x5x5x, 2nd line 1x4x4x3x1xxx1x3x4x4x1, etc.

7.31 Graphing: Graph paper is commonplace in galleries today, for many artists, op and otherwise, use it for drawings of proposed works. Bridget Riley is one of the foremost op artists, performing fairly complex graphing operations in the structuring of her paintings. An interview with her and/or other artists/ who develop their paintings in a similar way could be an exciting reinforcement to a program of simpler techniques for making geometric designs.

APPENDIX H

TESTING OF ASSUMPTIONS REPORT

A list of assumptions in each of Project ONE's five content areas -- Decimal Number System, Measurement, Estimation, Mapping and Scaling, Graphing -- arose during initial discussions concerning the mathematical curriculum of the television shows. These assumptions address existing mathematical abilities in the target population, minority children aged 8 to 11, and appear in Appendix B. They outline the minimum skills required of a student if he/she is to receive maximum benefit from the proposed television series.

At the end of June 1973, it became clear that the project staff had to validate its judgments about the existence of these minimal skills in the target population. In particular, the project needed a baseline from which to generate appropriate materials for both television shows and hands-on materials.

Accordingly, staff members designed and administered a series of activities or "games" to test the assumptions about the students' abilities in each of the five content areas. This initial process took place from June to September, 1973 at EDC, with the participation of 90 students from the Boston area and Project ONE staff members, and later with a total of 400 more children in Atlanta, Hartford, Los Angeles County, and Oklahoma City. Since the project is particularly concerned with the program's effectiveness in reaching minority children, most of the children who participated were chosen from urban schools. About 85% were children from minority groups, including Black, Spanish-surnamed, Oriental, and Native American.

Project staff also requested that participating students represent those classified by the school system as low achievers in mathematics. This was to obtain data that

would give an indication of base-level understanding in each content area.

We administered the Peabody Picture Vocabulary Test to the Boston students during the summer in order to obtain a very rough measure of I.Q. Students' past performances in the school systems other than Boston were assessed by the standardized test results available through the schools. Thus, the project has background data both from the work in Boston and from the four other participating school systems on the students' ability or achievement levels. However, we are not using these standardized test data to analyze results concerning students' abilities in the five content areas. Rather, this data merely gives an added description of the population we tested.

Standardized achievement tests alone are insufficient instruments for Project ONE because they do not provide appropriate measures of abilities of minority children. The language used in these tests is not consistent with the language encountered by these children; in addition, the items on the tests are frequently irrelevant to the child's experience and background. The multiple choice format requires certain skills that are peripheral to the mathematical concepts being tested; therefore, the scores are confounded by a child's test-taking abilities. Moreover, standardized achievement tests provide scores based largely on computation skills; they give little information about children's mathematical abilities in the areas of major concern to Project ONE.

Most important, paper and pencil tests, especially machine-scorable tests, give no insight into the problem solving techniques that children use, nor do these tests give any information about the various strategies that children may attempt or discard in the process of reaching a solution. As educators, the staff members who developed the Assumptions Study felt that the child's thinking process was more important than merely right or wrong answers, such as those found on standardized tests.

Design of Activities

One of the primary concerns in designing activities for the Assumptions Study was to minimize the need for students to read directions and to write responses. The format of game-like activities helped to eliminate the kinds of constraints inherent in standardized tests. This allowed a great deal of flexibility and gave the children room for considerable creativity.

Project ONE staff members adapted some of the activities from existing EDC curricula; others were created specifically for the purposes of this study.

All of the activities were designed to elicit the possible strategies a child might use to find the solution to a problem posed by the games. Therefore, most activities focused on the processes involved rather than on the actual answers given. The activities varied in format, providing opportunities to test each skill in a number of ways, and allowed staff members to sequence the games so that the children would experience tasks involving manipulable materials, pencil and paper exercises, and oral response activities in each content area.

Consider an example. One assumption in the area of Decimal Number System postulates that target population children are able to add pairs of numbers whose sums are less than or equal to 20. Two games that test for this ability are called "Two Cubes Throw" and "Three Cubes Throw". (The description below comes from the instruction manual for teachers.) The games used large wooden number cubes - first two cubes and then three. The games assessed the ability of a student to add mentally two numbers whose sum is less than or equal to 12, and the ability to add mentally three numbers whose sum is less than or equal to 18. The students became involved in the "game" of tossing the cubes and recording their sums after having guessed how many times a particular sum would occur within a given number of throws. The observer has time to assess each child's strengths during this process.

Counting and Ordering - Unit A

Game 7A Two Cubes Throw

Purpose:	To assess the ability to add two numbers mentally when the sum is less than or equal to 12.
Materials:	2 number cubes for each student Sheets with numbers 2-12 written on it
Directions to be read:	Each of you has two number cubes. You will toss the number cubes 36 times. How many times do you think your cubes will add up to 4? Write your guess on the other side of your paper. You may begin. As you add up each pair of numbers put a check on your paper next to the answer you get. For example, if you throw a 6 and a 5, you will put a check next to 11.
To the Teacher:	1. Encourage mental addition; however do not discourage finger counting or writing of numbers or marks when necessary. 2. Make sure students understand that they record the sums not the numbers thrown on the cubes. 3. Prevent them from "fixing" the cubes to produce the sum they want or changing the cubes to numbers that are easier to add. 4. Explain that there are no 9's on the cubes so that there will be no confusion with the 6's.

Counting and Ordering - Unit A

Game 7B Three Cubes Throw

Purpose:	To assess the ability to add three numbers mentally when the sum is less than or equal to 18.
Materials:	3 number cubes for each student Sheets with numbers 3-18 written on it
Directions to be read:	I will add one more number cube and ask you to throw three cubes 36 times. Before you begin, how many times do you think you will throw three numbers which add up to 13? Write your guess on the other side of your paper. You may begin. Try to add the number in your head. If you cannot then use paper to help.
To the Teacher:	1. Refer to instructions from previous game. 2. Encourage students who have difficulty adding mentally to group the cubes to make the additions easier.

A total of 42 activities tested all of the assumptions made in the five content areas. A teacher's manual for each content area described the purpose for each activity in that area, the materials needed, the objectives of the game, and specific instructions for conducting the activity. A brief description of the activities within the five content areas follows:

Counting and Ordering

Game 1 - Matching Bingo
Game 2 - "21" with Rook Cards
Game 3 - Boundary Bingo
Game 4 - The Bank
Game 5 - Jumbled Cards
Game 6 - Addition Tests
Game 7 - Two Cubes Throw and Three Cubes Throw
Game 8 - Subtraction Tests
Game 9 - 100 Board
Game 10 - Vocabulary

Examples of the kinds of materials used in the games are Bingo Cards, Rook Cards, play money, and numbered sequenced index cards. Another example from this unit is "Boundary Bingo": The child is asked to find a number on his game card that is one more than the number called by the teacher. This activity assessed the ability of children to recognize numbers at decade boundaries, e.g. 59 - 60 and at decade mid-points, e.g. 64 - 65. This unit (Counting and Ordering) required two hours of test time to complete.

Measurement

Game 1 Conservation of Length I
Game 2 Conservation of Length II
Game 3 Matching Units
Game 4 Matching Measure Units
Game 5 Marble Estimate

Game 6 Distance and Time I
Game 7 Distance and Time II
Game 8 Ticker Tape Estimates
Game 9 Units and Components
Game 10 Hand Spans

Some of the materials used in this unit were a cardboard framework arranged as a square; measurement question cards and unit cards; matching sheets for students; marbles, scales and cloth bags; ticker tape and scissors. An example of one activity from this Unit is Ticker Tape Estimates: Students were asked to "think about" the length of one foot and to cut off a length of ticker tape equal to one foot. They repeated the procedure for a yard and for an inch. This unit (Measurement) required one hour.

Estimation

Game 1 Dough Exercise
Game 2 Beakers I
Game 3 Beakers II
Game 4 Beans Exercise
Game 5 Relative Sizes Questions
Game 6 Number Estimation with Marbles
Game 7 Walking or Running Estimate
Game 8 Peas and Particles Pictures
Game 9 Cups in a quart; milliliters in a liter
Game 10 Measuring room with Meter Stick
Game 11 Trundle Wheel
Game 12 Cups of Objects
Game 13 One Pound Estimate
Game 14 Head or Waist?
Game 15 Weighing Objects

Some of the materials used in this unit were play dough; different sized containers, colored water; beans, marbles, cups, scales, trundle wheel, weights. An example of one activity from this

unit is Peas and Particles Pictures. Students were shown six different pictures, each one showing a varying number of different kinds of items. For example, one picture portrays people ice fishing on a large pond, with cars parked around the rim of the pond. Children were asked to estimate the number of cars and to write their estimate on the Student Answer Sheet. This unit (Estimation) required one hour.

Mapping

Game 1 Finding Shapes
Game 2 Pictures
Game 3 20 questions on a map

The materials in this unit included premarked sheets of paper with columns for each of several shapes: Circle, square, rectangle, triangle, half circle, octagon; picture package of 20 drawings; State map. In the "20 Questions on a Map" game, the child who was "it" was questioned about the location of a place on the map that he/she had picked. The players could ask questions to come as close as possible to the secret spot before asking about it by name. The players were encouraged to use directions: North, South, East, West, or left and right, and comparative distances. The first student to guess the place becomes "it" for the next game. This unit (Mapping) required one hour, although it was administered in two half-hour sessions.

Graphing

There were no assumptions made about prior abilities of the target population in graphing; therefore these four were teaching activities to see how easily children could pick up the basic concepts.

Game 1 Number Line
Game 2 Relay Race
Game 3 Graphing in Two Dimensions
Game 4 Graph-Toe

The materials used in this unit were a number line board, marker chips, rook cards, number line sheets, relay runners, and a quadrant coordinate graphing board. In the Graphing in Two Dimensions game, for example, the teacher marked some points on the graphing board, and asked the students to guess the special code used to name each point. Three points were named and counted out, e.g. (7,8). Students were asked to find those points which were closest to a target point. This unit (Graphing) required two hours, conducted in two one-hour sessions.

A Student Workbook contained all the paper that a student needed for all five units in the Study, including the Addition and Subtraction Tests, forms for recording the results of activities, questions from the estimation unit, number lines, graph-toe forms, etc. This booklet was filled out by each child in the Study as he progressed through the units.

Implementation

The basic design for the study involved one teacher and one observer working with a group of five children. The study was conducted on four consecutive days for two hours each day at a participating school. Teams of observers and teachers worked together to implement this study during one week in their school. For example, in Hartford, seven schools participated in the study with two to four teacher-observer teams in each school. Three teams sometimes conducted the study in a school simultaneously. A typical schedule for a study in one school involving three teams of teachers and observers appears on the following page. (During the study, an interview concerning television viewing habits was administered to each child individually over two half-hour sessions. This will be discussed below.)

The Project ONE staff felt that a group of five children would be large enough for interesting interaction to take place, yet small enough for individual attention to each participant.

SUGGESTED SCHEDULES

		Day 1	Day 2	Day 3	Day 4
TEAM 1	*First Hour*	A_1	B	A_2	C
	Second Hour	I_1 & D_1	E_1	I_2 & D_2	E_2
TEAM 2	*First Hour*	C	E_1	B	E_2
	Second Hour	D_1 & I_1	A_1	D_2 & I_2	A_2
TEAM 3	*First Hour*	D_1 & I_1	A_1	D_2 & I_2	A_2
	Second Hour	E_1	B	E_2	C

Each Team: 1 teacher, 1 observer, 5 students

A_1, A_2: Counting and Ordering
B: Measurement
C: Estimation
D_1, D_2: Mapping and Scaling
E_1, E_2: Graphing
I_1, I_2: Interview

A_1, A_2, B, C, E_1, E_2 require 1 hour each

D_1, D_2, I_1, I_2 require 1/2 hour each

Interview personnel will include 1 teacher, 1 observer and 3 permanent interviewers.

The activities in this study were administered in an atmosphere unlike a typical testing situation. Children worked in groups of five, and were encouraged at times to interact with one another, either by working together or in discussions of possible strategies during a game.

Approximately 500 children were tested in five cooperating cities across the country: 70 from Atlanta, 90 from Boston, 90 from Hartford, 150 from Los Angeles, and 90 from Oklahoma City. Local administrators in these cities selected teachers and observers for the Assumptions Study from learning center consultants, classroom teachers, substitute teachers, and master teachers. Additional staff to conduct the oral interview on television viewing habits were selected from community workers and teachers' aides.

The study employed an observational method. Because the project required particular kinds of data, the research model used a trained observer for each small group of students. Clinical observations giving insight into children's reasoning, thinking processes, attitudes, and behavior helped us to understand better the children's performance on specific mathematical tasks. Often a child's performance relates to the dynamics of past experience including peer pressure, and this kind of information we obtained is invaluable in assessing a child's capabilities.

By minimizing the reading/writing component, and by supporting the participants in such a way as to elicit the best possible mathematics involvement, we helped the children feel comfortable and encouraged them to talk, work together and share their reasoning and explanations of their actions. In this way, observers were able to record as much of the activity as possible, including verbal remarks, mannerisms that gave insight to the child's thinking process, working methods, game processes, and outcomes that provided evidence of each individual's mathematical ability.

Roles of Teachers and Observers

Teachers were able to assist children when they had difficulties, probing their reasoning in an effort to find how mistakes occurred and providing hints in order to aid the child in discovering other approaches to a problem. By having the teacher work with the students, the child's thinking process emerged more clearly, and the observer was able to obtain a better understanding of each child as an individual. It was important for the teacher to be aware of his/her newly defined role in this unique evaluation project. Teachers were instructed not to intervene in the activities unless a child was terribly frustrated by not succeeding, or by not understanding the rules of the game. If, however, a child was proceeding smoothly but responding incorrectly, the observer noted whether the other children pointed out the incorrect responses, or if the child was able to correct them himself. In activities having each child work independently, a teacher might assist a child after the observer had recorded the necessary information about the student. The observer then noted whether the child was able to understand the task after being assisted. Only in graphing games, for which we assumed that children would not have any relevant previous experience, did we do teaching in the traditional sense. The teacher's primary functions were to introduce the game activities and to make sure that each child participated to the best of his/her ability. The staff provided detailed instructions for each game to assist teachers in their roles.

Training

EDC staff members traveled to the participating cities to train teachers, observers and interviewers -- the staff for the Assumptions Study in each school system. The Project ONE staff had first tested the instruments with a pilot group of 30 students in Boston, and trained a group of people to complete the Study in Boston with 60 more children. This gave us the opportunity to revise the instruments and to develop training procedures for the other cities.

Training sessions were conducted with both teachers and observers present; in this way, they had a better understanding of how components in the research model were to interact. Teachers themselves played most of the 42 activities included in the study as part of their training, and observers had the opportunity to watch. The EDC staff worked with observers to help them function in their role, as well as to assist the teachers in understanding the procedures of the activities. Observers were trained to record their data on printed observation forms (see next page) which provided: 1) a brief reminder of the major objectives for each game, 2) space for clinical observations on individuals and on the group, and 3) a section for translating behaviors into the special codes developed for each activity. Copies of the observer forms for two of the games described above -- Two Cubes Throw and Three Cubes Throw -- appear on the following two pages. A separate observation form for each activity provided different codes and comments to the observer.

Observers were asked also to check the children's work sheets produced in some games, for additional information on their mathematical ability. The codes used by observers reflect clinical observation, making distinctions among those children who succeed immediately at a given task, unquestionably understanding the mathematical concept; those who succeed after some trial and error; those who employ unique strategies which lead to appropriate solutions; and those who lose interest or become distracted.

Observers were trained to record as much information as possible on the left side of the observer forms about each child's performance during an activity. Specific behaviors which we had observed previously in Boston students were pointed out to observers during the training sessions in order to help them be aware of all the possibilities they might encounter. Observers were asked to circle the appropriate codes in the box on

A Two Cubes Throw

Observer

Date

Game 7a

Spend a few moments looking at each child individually, checking for his addition methods, accuracy, etc.

AM = Adds mentally
DA = Has difficulty adding
CF = Counts on fingers
CA = Counts aloud
VR = Uses visual representation
GR = Groups dice

		OK AM DA CF CA VR GR
		OK AM DA CF CA VR GR
		OK AM DA CF CA VR GR
		OK AM DA CF CA VR GR
		OK AM DA CF CA VR GR

A Three Cubes Throw

Observer | Date

Game 7b

Observe similarly to 2 Dice Throw Game.

AM = Adds mentally
DA3 = Has difficulty adding 3 numbers
CF = Counts on fingers
CA = Counts aloud
VR = Uses visual representation
GR = Groups dice

OK
AM DA3 CF CA VR GR

OK
AM DA3 CF CA VR GR

OK
AM DA3 CF CA VR GR

OK
AM DA3 CF CA VR GR

OK
AM DA3 CF CA VR GR

the right side of the form after they had written out their descriptions on the left side of the form, and had gained an impression of the participant's ability.

Since the Assumptions Study was the initial activity of Project ONE involving the school systems, the project provided training materials along with materials for conducting the study. These served as a focus for the training sessions, given a few days before the actual Study itself was to begin.

Television Viewing Habits Interview

On two different days of the Assumptions Testing Project, we arranged to set aside a half-hour for the television viewing habits interview. Both teachers and observers participated in this part of the Study; however, additional staff were needed to conduct the oral interviews -- one with each individual child. These additional people, along with the teachers and observers, were trained to administer the interview.

The interview itself was designed to document the use of television, program preferences, attitudes towards television, reaction to existing educational and minority-oriented programming, school television use, suggestions for television programming, and other related topics. The staff was particularly interested in which television characters a child identifies with and why; the credibility of television compared with other media, friends, siblings, and parents, and the type of format a child would like to see for a new math program. Portions of the interview were drawn from previous interview studies so that results from this project could be correlated with existing literature on preferences of majority children. These interviews served to provide Project ONE with needed information; we felt that detailed information about the media preferences of minority children could further aid the development of the new television shows.

Some existing literature on children's viewing patterns documents the amount of time spent watching television as well as

the general trends in children's content preferences.* Other studies speak to the frequency of viewing in relation to age and sex. Patterns of minority usage in particular have been studied less intensively. The recent work of Lyle and Hoffman,† on exposure patterns of children to media, reports data similar to that collected in 1961**; neither study, however, included significant numbers of minority children in the sample. Of the more than 1,800 students questioned in the Los Angeles area, only 60 were Black, and 15 were Asian or Indian (Lyle and Hoffman, 1972). Mexican Americans represented roughly 15% of the sample. Due to these low proportions and low response rates, it was frequently difficult to analyze data by racial or ethnic group membership.

The information provided by these published studies was not sufficient to answer questions about specific media habits of non-white children. In particular, the data did not reflect recent changes in television programming. One important change has been the inclusion of minority people in nationwide network television programs; another has been the increase in the number of educational programs. It was important for our purposes to see how viewing patterns had been affected by these changes.

We designed an interview to provide information on a variety of issues relating to television use adapting the format from existing interviews and questionnaires on viewing habits,

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* Lyle, J. "Television in daily life: Patterns of use (overview): *Television and Social Behavior*, Vol. 4, Washington, D. C.: U. S. Government Printing Office, 1972.

† Lyle, J., and Hoffman, H. R. "Children's Use of Television and Other Media" in *Television and Social Behavior*, Vol. 4, Washington, D. C., U. S. Government Printing Office, 1972.

**Schram, W., Lyle, J. and Parker E. B. *Television in the Lives of Our Children*. Stanford: Stanford University Press, 1961.

and including specific modifications that would serve to address our particular concerns*.

The staff was especially concerned about the impact of minority oriented programming on the target population. Further, in light of the experiences of Children's Television Workshop in attracting minority viewers, we needed to learn about the extent to which members of the target population tended to seek out educational children's television.

We chose an individual interview format to ensure valid data. The use of a questionnaire would have required skill in reading; in order to include the opinions of children of varying ability in language arts we chose the interview format instead. This individual approach was consistent with the general atmosphere of the Assumptions Testing Project.

After an initial test of the entire Study in Boston, we modified the interview and expanded the section on suggestions for television. Children proved very resourceful in offering alternative programming suggestions. The following are two questions from the Television Viewing Habits interview, taken from the interviewer's form:

KID POWER

1) Have you seen it?
   a) yes b) no
2) Do you like it?
   a) yes b) no
3) Why do you (dis)like it?
4) How often do you watch it?
   a) once a week
   b) once a month
   c) twice a month
   d) other (# of times) _____

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* Lyle and Hoffman, 1972; and Lyle, J. and Hoffman, H.R. "Explorations in Patterns of Television Viewing by Preschool-age Children" in *Television and Social Behavior*, Vol. 4, Washington D.C.: U. S. Government Printing Office, 1972; and Bechtel, R.B., Achelpohl, C., and Akers, R., "Correlates Between Observed Behavior and Questionnaire Responses on Television Viewing" in *Television and Social Behavior*, Vol. 4, Washington, D.C.: U.S. Government Printing Office, 1972.

5) How many times have you seen it in the past?

a) every week
b) once
c) never
d) other (# of times) _____

Is there one type of program that you would like to see more of on TY?
(type: adventure, comedy, cartoon, monster, variety, etc.)

a) yes
b) no

If yes:

a) Why would you like there to be more _____ ?

We developed a special code for the Television Viewing Habits Interview. All interviews were coded by a part-time coding staff specifically trained for this task. (At this writing, the coding has just been completed.) Data gathered from the interview should provide Project ONE staff with new information about the specific habits and preferences of minority group children, and about various sub-groups within the target population.

Reactions of Study Participants

Before discussing statistical results of the Assumptions Study, it is worth mentioning the reactions of teachers and students who participated. During the training sessions, teachers were excited about the unique approach and enthusiastic about the way materials were designed and used. Many of the teachers kept the materials for later use in their own classrooms for mathematics, science, and other related areas.

The Learning Center teachers of the Oklahoma City Public Schools planned to use the games in teaching situations, and conducted a workshop for a parents' group so they could duplicate some of the games for use in school. The Project ONE

Coordinator for their schools reported a high level of enthusiasm on the part of both students and teachers.

In Los Angeles County, the teachers who participated in the Assumptions Study felt that they had gained many good ideas and techniques for mathematics instruction. A few comments from the Lennox School District of Los Angeles County:
"Many activities and games were excellent and were thoroughly enjoyed by children."
"The manipulative activities were enjoyed most by the children."
"Pupils were very cooperative, interested and motivated by the entire project."
"Many good ideas and techniques for mathematics instruction were gained from participation in the Project."
Similar comments came to the Staff from the other participating cities.

In Atlanta, the teachers decided to use many of the materials in their science classes; they incorporated the Mapping Game into their social studies activities area, and the teachers thought that the 100 Board was a good way to encourage children in working together. In Hartford, teachers in one school arranged a way to share the materials located in their school.

Students responded very favorably to the use of manipulative materials in the activities; teachers and observers both mentioned the students' enjoyment in playing the games and working with the materials. This reaction has been described in some detail because the materials of the Assumptions Study is the first classroom contact Project ONE has had with the participating school systems. The favorable reception by teachers, parents, students, and administration to the use of hands-on materials for teaching mathematics is definitely encouraging.

PRELIMINARY RESULTS OF A SELECTED SAMPLE

At the time of this report, the computer analysis of all data from the Assumptions Study is not yet complete. However, an analysis on a selected sample (50 of the 490 children) has been calculated for certain activities and skills in the five content areas, and for specific television interview questions. Two groups of five children were randomly selected from each of the five cooperating cities: Atlanta, Boston, Hartford, Los Angeles County and Oklahoma City. The sample reflects information from two different teacher/observer teams in each city.

The Assumptions Study gathered three basic kinds of data on each child:

1) Identification data -- For each child in the Assumptions Study, there is information on age, sex, ethnic group, number of children in the family, birth order of child who participated in study, IQ or achievement test scores, grade in school, number of days in program, identification of group observers, and characterization of classroom.

2) Television Viewing Habits Data -- Information includes the viewing habits of children in the study; i.e. favorite programs, reasons for liking and disliking programs, attitudes toward television, and reactions to existing educational programs, minority-oriented prime time programs, and minority-oriented cartoons. School television use, suggestions for television, and other related information was also obtained from the interview.

3) Mathematics performance -- Information on the specific mathematical abilities, and the strategies and heuristics employed by the children in the target population came from the observer forms used during the Assumptions Study. There are data from the coded section of the observer forms, as well as from the written observations on each child, concerning his/her performance in the five content areas: Decimal Number System, Measurement, Estimation, Mapping and Scaling, and Graphing.

ASSUMPTIONS STUDY

Specific Skills and Strategies Within the Content Areas

The preliminary results discussed here may or may not be indicative of findings from the larger group; however, they will give insight into the kinds of skills tested and the procedures used to understand the capabilities of each child.

Decimal Number System

Within the Decimal Number System content area, there were 10 games; however, within those 10 games, information on at least 40 different skills and processes was collected. Some of these skills were pulled out for small-sample manual analysis. In a game called Boundary Bingo, for example, the children were asked to find a number on their game card which would be one greater than the number called by the teacher. In this way, the observer was able to note if a child had difficulty at the boundaries (59 to 60, 99 to 100, etc.) or difficulty at midpoints (64 to 65, 16 to 17, etc.). The results of the small sample showed that 13 out of 50 children, or 26%, had difficulty at boundaries and 9 out of 50 children, 18%, had difficulty at midpoints.

The Bank is a game which assessed the child's ability to count money, divide the money by manipulating, and divide

numbers. Nine children out of 50, or 20%*, had difficulty counting money, which was presented in denominations of fives and tens; another 20%* were only able to count sums of money under one hundred. The remaining 60%*, or 27 children out of 50, were able to count money whose sums exceeded $100.

Two forms of a written addition exercise were administered to the children. Twenty-five problems were presented in horizontal notation and twenty-five other problems presented in vertical notation. The answers to these problems were numbers less than or equal to 20. The findings from the small sample showed that the children performed equally well on both forms of the addition exercise: 74% had perfect scores on the horizontal form, and 76% had perfect scores on the vertical form; only 2% had scores of three to five errors on both forms.

The ability to add mentally was observed in several different situations; 40 children out of 50, or 82%*, were able to add mentally two numbers whose sum did not exceed 12. In this activity, children tossed number cubes, and recorded the sum on each throw. When a third die was introduced to the activity, and children were then asked to add three numbers whose sum was less than or equal to 18, 59% of the sample of 50 were able to add mentally. 73% of the sample showed no difficulty in adding the three dice, but employed other methods of arriving at the solution, such as grouping the dice, counting aloud, or counting on fingers in a systematic fashion.

One assumption concerning multiplication stated that most children do have difficulty with the conventional algorithm for this operation, and that many children think of multiplication as repeated addition. The sample of 50 showed that 30% could multiply only with help from peers or the teacher. (In many cases this meant the child might be reminded of the process of repeated addition, or inadvertently rediscover the process when using visual representation of the numbers.) Of the small sample, 8% were unable to perform multiplication at all.

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* There is some missing data for certain children on particular skills. Consequently, these percentages are based on the number of students who participated in that particular activity, not always on the full sample of 50.

Measurement

The content area on measurement included ten activities involving a minimum of 18 different skills and strategies. Many of the activities in this area involved an understanding of the units of measure within a given type of measurement, such as length, weight and time.

In one activity children were asked to demonstrate appropriate units of measure for length, weight and time. Observers noted whether a child would confuse units within one measurement category, such as inches instead of feet for length, or whether a child chose an inappropriate unit for a category, miles instead of hours for time. Thirty-seven out of 50 children, or 74%, showed an ability to use appropriate units of measure. Sixteen percent, eight out of 50 children, chose the wrong unit for a category of measurement. Four percent confused units of measure within a category of measurement.

In one exercise within the area of measurement, children were asked to answer questions such as: How many inches are there in a yard? How many minutes in an hour? How many ounces in a pound? Following that exercise, children were given a multiple choice for the same kinds of questions. There was little difference in the numbers of children who were successful at choosing the right answer from multiple choice and those who were able to produce the correct answers in the measurement of length; 44%* chose the correct answers from multiple choice for the category of length. Thirty-eight percent were able to produce correct answers in the measurement of weight; 44%* chose correct answers in the multiple choice for that category. Eighty percent produced correct answers for the measurement of time; 82%* chose correct answers given in the multiple choice.

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*See footnote on page H.20.

Estimation

In the area of Estimation, assumptions were that children in the target population have some qualitative estimation ability, and can estimate quantities of small numerical value, but that they would have difficulty in estimating large numbers. Children in the study were asked to estimate many kinds of things in the fifteen activities making up this content area. For example, they were asked to estimate how long it would take a member of their group to walk from one end of the room to the other end and back. The observer recorded the children's estimates. After the group member had walked the length of the room and back, the children were asked to make a second estimate. Forty-two percent* or 20 children out of 50, had two good estimates or had improved on the second estimate. Fifty-eight percent* or 28 children had fair or poor estimates in this activity.

There were two types of small quantity estimation activities. One involved distribution quantity; children were asked to estimate how many cups in a quart, how many meter sticks would fit across the room, and how many complete turns it would take for a trundle wheel to cross the room. Twelve children out of 50, or 24% made accurate estimates in these three activities; 57% made fair estimates, and 18% made poor estimates. Another type of estimation activity involved numerosity of four different quantities, each totaling less than 12. Twenty-one out of 50 children or 48%* made accurate estimates on all four quantities; 34%* or 15 children made fair estimates and 18%* made poor estimates.

Mapping and Scaling

The Mapping and Scaling unit of the study contained three games. It is interesting to note that the children in the small sample of 50 were equally divided in ability on many skills as observed in these activities. Twenty Questions on a

*See footnote on page H.20.

Map tested the children's ability to read a map, learn from others' questions, and follow directions. 55% of the 50 children exhibited an ability to use directions of left and right, while 45% were not able to use these directions in game playing. Forty-nine percent of the 50 children understood, and were able to use cardinal directions -- North, South, East and West. Fifty-one percent were not able to use cardinal directions. Fourteen out of 50 children were able to ask appropriate questions while playing Twenty Questions on a Map, demonstrating a basic understanding of maps. Another 14 children were able to ask good questions after observing a model set by the adult player or other children, while 21 children showed no apparent understanding of maps. Children in our small sample were evenly divided in their ability to read a map; 26 children out of 50 were able to read a map, while 23 children showed little or no ability in map reading.

Graphing

The content area on Graphing includes four games. Because we had made no assumptions in this area, some teaching took place, and we made observations on how well a child was able to transfer information from one activity to the next. A two dimensional graph and ordered pairs of numbers were introduced to the children; after examples of ordered pairs were given, and the points those pairs represented were demonstrated, the children played a game involving these skills. In the first activity, Graphing in Two Dimensions, the children in the sample of 50 were almost equally divided between those who exhibited an initial understanding of the ordered pairs (41%*) and those who were able to comprehend ordered pairs as the game progressed (50%*). In the game Graph Toe, 83% of the 50 children who understood ordered pairs were able to play the game well and had shown that they transferred information learned in the previous activity. The remaining children who

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* See footnote on page H.20.

played Graph Toe were evenly distributed between those who demonstrated difficulty in using ordered pairs to call points, and those who showed little or no understanding of the game.

Data Analysis

A percentage score was computed for each student on the basis of his/her performance on the activities within each content area. (Figures 1 - 5) For example, there were ten activities in Decimal Number System calling on forty skills or kinds of strategies. On the basis of these forty skills, we arrived at a score for each student in the small sample. Because there were some missing data for certain children in particular skills, percentage scores of performance were computed from existing information on each child. Thus, equivalent percentage scores, e.g. 75% in Decimal Number System, do not necessarily represent performance in the same activities within that content area.

The analysis of the data for this sample (n=50) was limited for now to a frequency distribution representing performance in each of the content areas and to computations of the mean and standard deviation for each content area (Figure 6).

A discussion of the variance exhibited by the data would not be appropriate here, because it is not certain whether the data representing the sample of 50 will actually be representative of the sample of 490. Several experimental variables may account for some of the variance. One of these may have been the effects of the age distribution (8 - 11 years). An analysis of the data with age held as a constant may yield important age trends in terms of performance across the content areas. This age distribution reflects a diversity in school grade placement which may in itself partly account for the distribution of student performance. In addition, performance trends may be found in reference to the other demographic variables (e.g. sex, achievement, test scores, and ethnicity), which were not analyzed for the subsample (n=50).

The overall focus of this study was to obtain information about the processes students used in approaching various mathematical activities. Students were able to exhibit their level of proficiency, and a variety of heuristic strategies were assessed.

A future error analysis of student performance may yield important information as to which strategies are employed by the larger sample (n=500) when dealing with mathematical activities. Such an analysis could provide invaluable information for designing the mathematics curricula of Project ONE.

ASSUMPTIONS STUDY
DISTRIBUTION OF PERFORMANCE IN EACH CONTENT AREA

$n = 50$

FIGURE 1- DECIMAL NUMBER SYSTEM

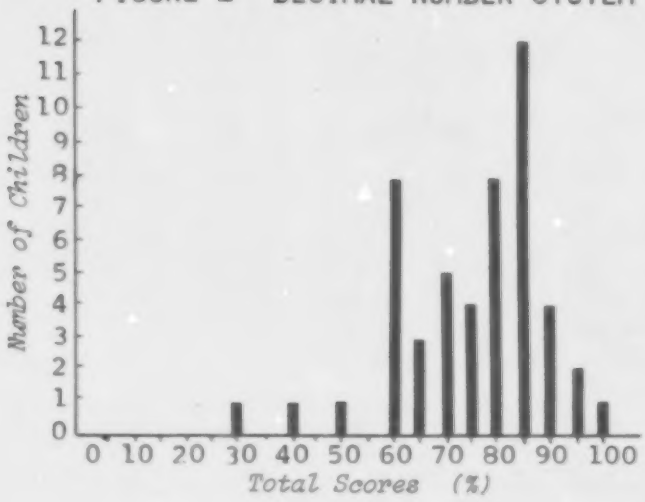


FIGURE 2 - MEASUREMENT

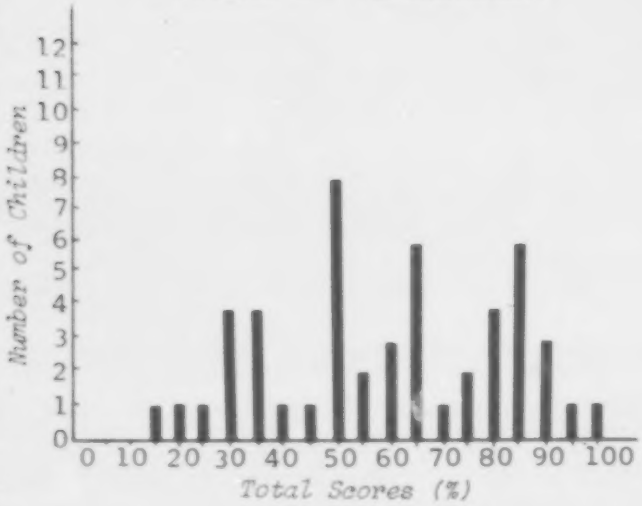


FIGURE 3 - ESTIMATION

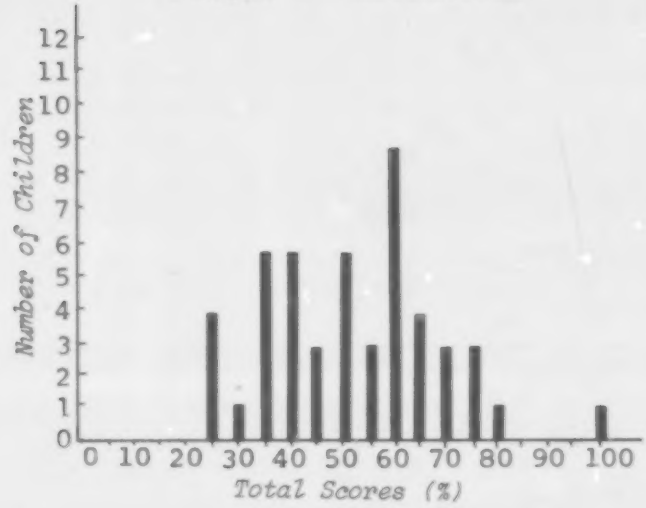


FIGURE 4 - MAPPING AND SCALING

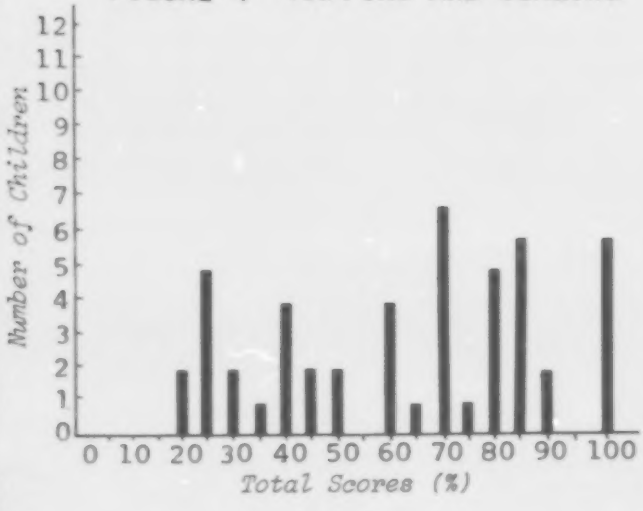


FIGURE 5 - GRAPHING

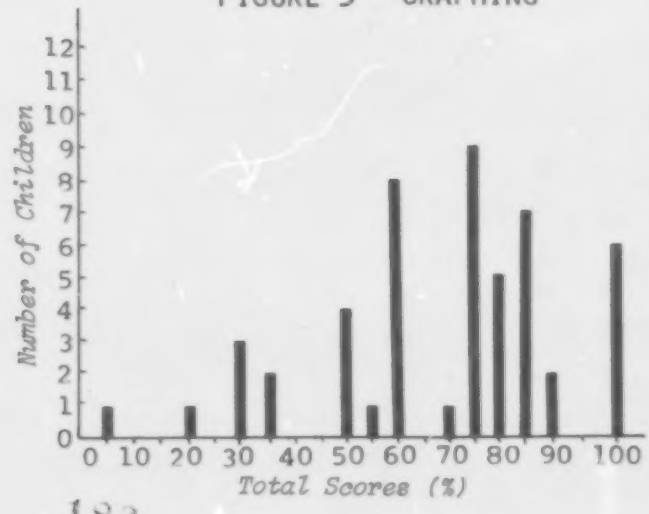
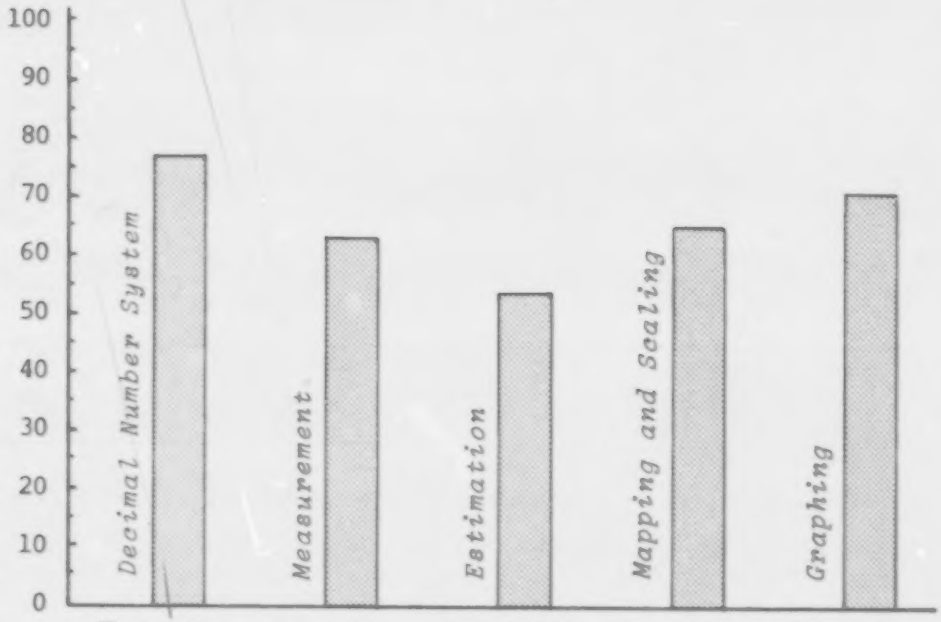


FIGURE 6 - ASSUMPTIONS STUDY MEAN SCORES FOR EACH CONTENT AREA

$n = 50$



*$\bar{x}$ = arithmetic mean

**s = standard deviation of sample data

TELEVISION VIEWING HABITS INTERVIEW

Preliminary Results

Complete results of the television viewing habits interview, given to the children as a part of the Assumptions Testing Project, are not yet available. The data from the interview, which was administered by an adult and recorded on prepared forms, has been reduced to numerical codes to facilitate computer analysis, which will take place shortly. Data concerning the 50 children in our subsample were extracted and certain items of particular interest were examined; a report of these preliminary results follows.

One of the fundamental areas covered in the Television Viewing Habits Interview was the amount of television viewed by children in our target population. In particular, results indicate the number of hours per day the children watch television on a normal school day. The findings for the sample population are as follows:

On the average school day,

16 of the 50 children watch between 1/2 - 2 hours per day

14 of the 50 children watch TV between 2 1/2 - 4 1/2 hrs. per day

13 of the 50 children watch TV between 5 - 6 1/2 hrs. per day

5 of the 50 children watch TV between 7 or more hours per day.

There was little variation among the children in the number of days of viewing television during a week. Forty-four out of the sample of 50 watch five days or more, while 5 of them watch 3 or 4 days and one watches one or two days each week.

Favorite shows for this group of children fall into several categories: situation comedy, children's educational, music/variety, cartoons, family situation comedy, and adventure.

Those most popular with this group are listed below. (Two responses from each child were tabulated.)

Number of Students	Show	Number of Students	Show
6	Sanford and Son	1	The Waltons
		1	Kung Fu
5	Electric Company	1	Lone Ranger
5	I Dream of Jeannie	1	Porky Pig and Friends
5	Lucy	1	Bowling
5	Zoom	1	Emergency
		1	Flintstones
4	Star Trek	1	Movies
		1	Banana Splits
3	The Rookies	1	Super Friends
3	Gilligan's Island	1	Bugs Bunny
3	Father Knows Best	1	Kimba
3	Hawaii 5-0	1	The Little People
3	Brady Bunch	1	Bonanza
3	The Partridge Family	1	The News
3	Flip Wilson	1	M.A.S.H.
		1	Underdog
2	Mod Squad	1	Wrestling
2	Leave It To Beaver	1	Fat Albert
2	Dennis the Menace	1	Baseball
2	Batman	1	Dick Tracy
2	Cartoons (any)	1	Road Runner
2	Three Stooges	1	Pink Panther
2	Mannix	1	Mighty Mouse
2	Shaft	1	The Magician
2	Andy Griffin Show	1	Barnaby Jones
		1	Hogan's Heroes
		1	Wild, Wild West
		1	Ozzie's Girls
		1	Miss U.S.A.

These children were anxious to share their reasons for choosing certain programs as their favorites. Twenty-five percent of the responses reflect the sample's enjoyment of specific program characters in terms of the behavior, appearance, ethnicity or other personal qualities shown in the program. Another 23% of the children chose their favorite shows because of the humor. Unquestionably, the phrase "It's funny" appeared more often than any other comment elicited from these children.

Informative or educational aspects of certain shows appeals to 10%; action and adventure attracts another 10%, while the formats of certain shows appealed to a third 10% of these children. Project ONE must consider these responses carefully during the development stages of the program.

The popularity of cartoons among these children is unquestionable; 48 out of the 50 watch cartoons and list the following programs as their favorites:

Number of Students	Show	Number of Students	Show
9	Super Friends	1	Osmonds
		1	Speed Racer
6	Flintstones	1	Batman
		1	Rescue Ranger
5	Bugs Bunny and Friends	1	Kid Power
		1	Mission Magic
2	Speed Buggy	1	Three Stooges
2	I Dream of Jeannie	1	Smokey the Bear
2	Saturday Superstars	1	Sealab 2020
		1	Underdog
1	Emergency Plus Five	1	Cashy Kids
1	Cartoons Carnivals	1	Cartoon Specials
1	Archie Sunday Funnies	1	Mighty Mouse
1	Huckleberry Hound	1	My Favorite Martian
		1	Touche Turtle

Three special classes of programs were of particular interest to the project: Children's educational programs, minority oriented cartoons, and minority oriented prime time programs. Reactions to specific programs in each category were examined in some detail, yielding information about the popularity of each show, viewing frequency, and reasons for enjoying or not enjoying each program discussed. Figures 7 through 12 contain the results of the sample. It is interesting to note that although one-half to two-thirds of these children express some degree of enjoyment for Zoom, Electric Company, Sesame Street, and Multiplication Rock, these same programs did not receive a proportionate number of responses among the favorite shows listed.

At least one-fourth of our sample is unfamiliar with several of the children's educational programs in question, in spite of their nationwide coverage. Viewing frequency results show that Multiplication Rock is watched every week by 30 of the 50 children, or 60%; apparently the positioning of this brief program in the midst of Saturday morning cartoons has been beneficial. Of the minority oriented cartoons discussed, Jackson Five and Fat Albert were by far the most popular. It is interesting to note that of those children who watch the minority oriented cartoons, very few expressed dissatisfaction with them. Also, those children who watch minority oriented cartoons do so on a fairly consistent basis; for example, 30 of the 35 children who watch Kid Power do so every week. Prime time programs which involve members of minority groups on a regular basis also were favorably regarded by this population. Kung Fu, Flip Wilson, and Sanford and Son took the lead. Although these programs were designated for older audiences, children aged 8 to 11 in the target population find them entertaining. As in the case of the minority oriented cartoons, the majority of the children who viewed these prime time shows watched them every week. In considering the viewing frequencies for each of these three classes of programming, results show that each month the average child in this group watches at least 12 children's educational programs, 13 minority oriented cartoons, and 15 minority oriented prime time programs.

FIGURE 7 - POPULARITY OF CHILDREN'S EDUCATIONAL PROGRAMS

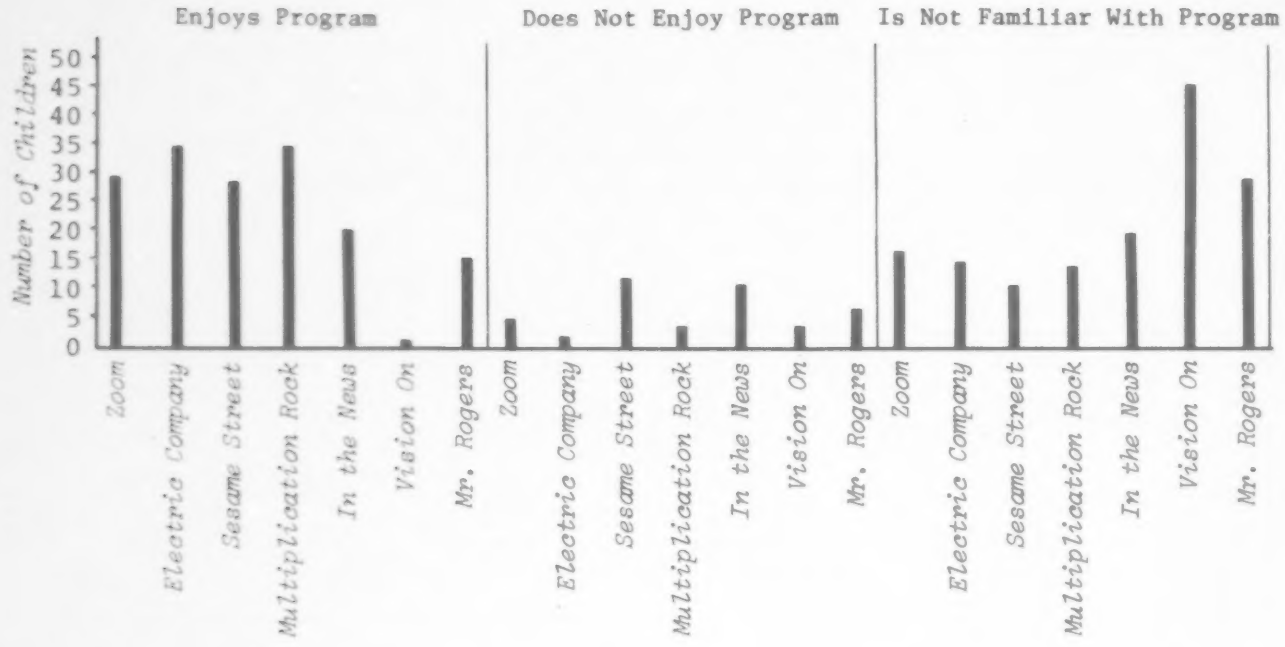


FIGURE 8 - POPULARITY OF MINORITY-ORIENTED CARTOONS

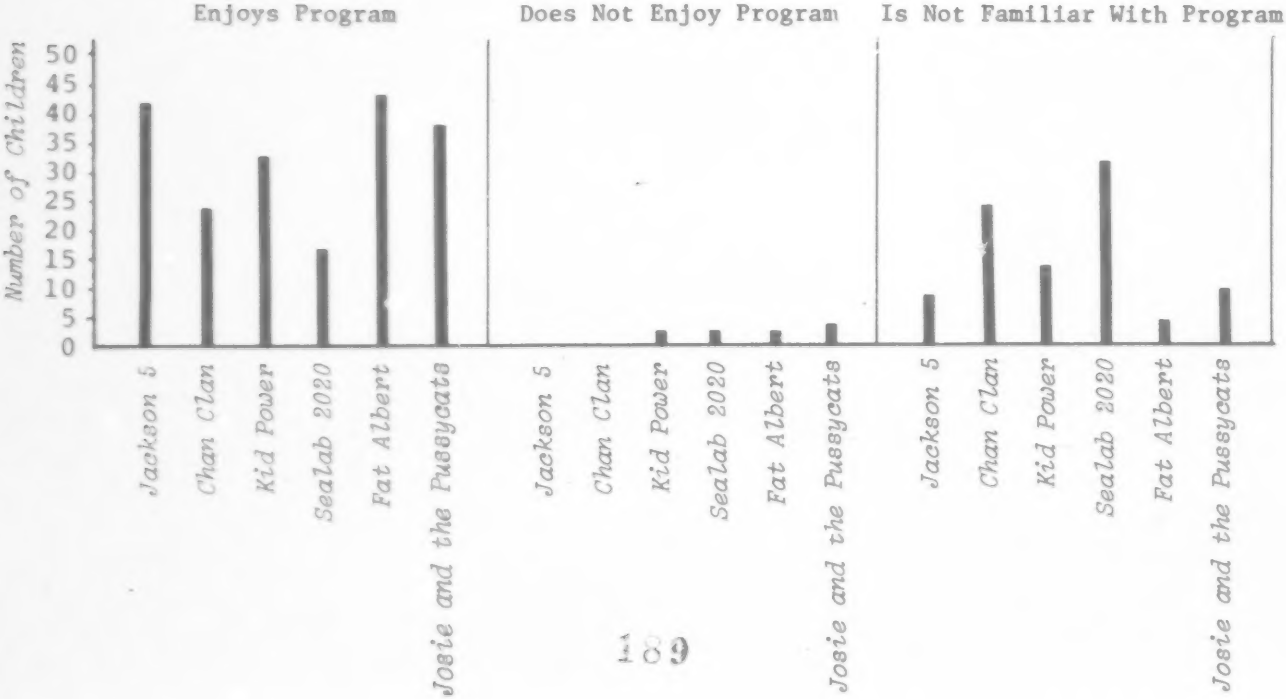
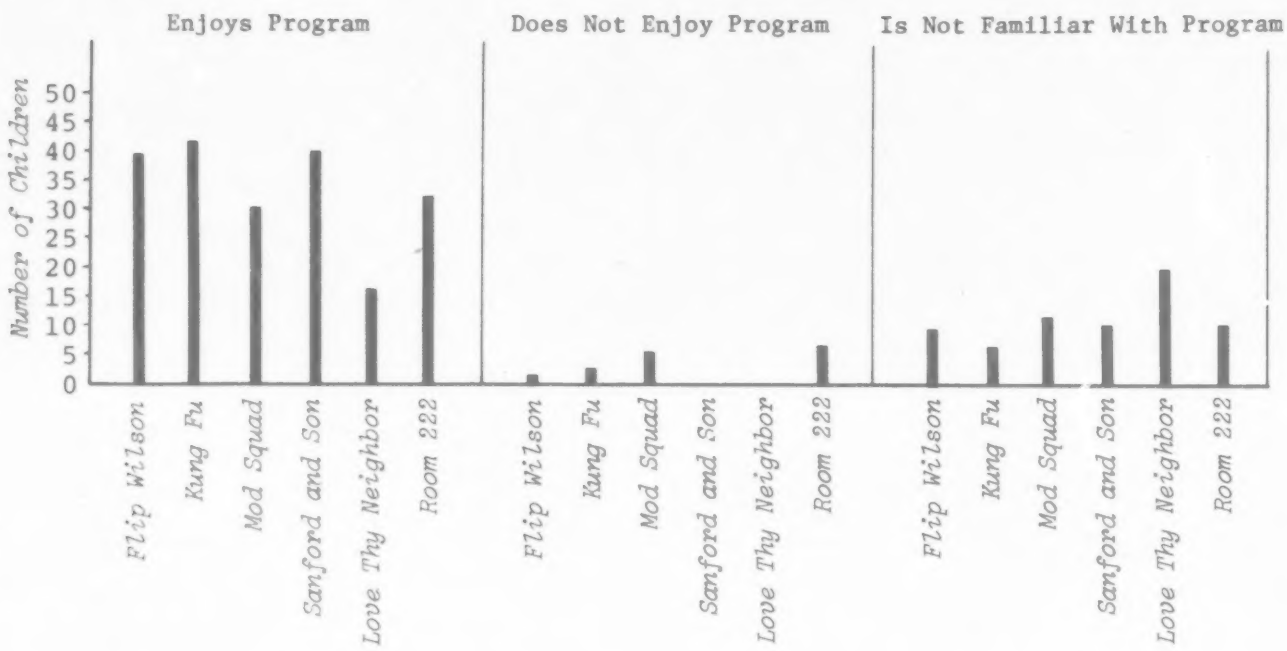


FIGURE 9 - POPULARITY OF MINORITY-ORIENTED PRIME TIME PROGRAMS



MINORITY-ORIENTED PRIME TIME PROGRAMS

VIEWING FREQUENCY (PER MONTH)

	Never	Once	Twice	Three	Four	Five or More	Undetermined
Flip	8	2	1	-	36	-	1
Kung Fu	6	3	4	-	32	-	3
Mod Squad	11	3	3	-	19	2	7
Sanford & Son	9	2	2	-	34	-	2
Love Thy Neighbor	19	-	2	-	12	-	2
Room 222	10	3	2	-	29	-	4

CHILDREN'S EDUCATIONAL PROGRAMS

VIEWING FREQUENCY (PER MONTH)

	Never	Once	Twice	Three	Four	Five or More	Undetermined
ZOOM	17	2	2	-	11	10	7
Electric Company	15	1	1	-	11	13	9
Sesame	13	1	2	-	13	9	9
Multiplication Rock	13	-	-	-	30	1	5
In the News	20	1	1	-	19	1	7
Vision On	45	1	-	-	1	-	1
Mr. Rogers	29	-	1	-	11	4	3

MINORITY-ORIENTED CARTOONS

VIEWING FREQUENCY (PER MONTH)

	Never	Once	Twice	Three	Four	Five or More	Undetermined
Jackson 5	7	1	1	-	30	2	7
Chan Clan	24	2	1	-	15	1	4
Kid Power	13	1	1	-	30	-	3
Sealab 2020	31	1	2	-	13	-	1
Fat Albert	5	2	4	-	22	1	4
Josie & Cats	9	3	-	-	30	-	4

In another section of the interview, children were asked to name programs which involved certain minority group members. We felt that the results of this section would contrast somewhat with those previously presented on minority oriented cartoons and prime time programs. There were indeed some interesting features; although more than 80% of the 50 children watch and enjoy four of the minority shows which include Blacks, only 68% of them were able to name two shows involving Blacks in the free response section. Also, 84% of the 50 children watch and enjoy Kung Fu; however only 22% of them were able to name a program which includes Chinese people. Even smaller percentages of the children were able to recall programs involving Spanish-speaking or Native American persons.

In line with the project's need for information about characters with whom children in the target population identify, we developed additional questions to probe this issue further. Responses show that 32 of the 50 children do identify in some way with certain children seen on television. Also, 19 of them feel that certain adults on television resemble their parents. We noted that physical appearance was the most dominant characteristic with which the children identify, although seven children also stated ethnicity or personal behavior as reasons for identification.

Those questions which elicited specific suggestions for television deserve some mention. Of 50 children questioned, 11 would like to see more cartoons on television; 9 prefer to view more horror or monster shows, while 8 would include more general comedy if given the opportunity to increase certain types of programs. It was also interesting to note that nearly half (23) of this population have a desire to see more of a specific type of character, such as more Blacks or more Native Americans, rather than a broader category of characters such as puppets, adults, children, or animals. However, ten percent of the children did mention that they would include more cartoon characters on television, this being consistent with the over-

whelming popularity of cartoons with this particular group. Children were given the opportunity to talk about the design of their own television program; the responses varied greatly among these 50 children. Nine programs would be cartoons, 6 children's educational, 5 family situation comedy, 4 horror or monster, and three each of the following: Detective, variety, cultural, and general comedy.

Several aspects of school television use were investigated -- notably the availability of sets in school and types of programming children view in their classrooms. Forty-two of the 50 children in the sample attend schools which have television sets; these children may or may not watch television on a regular basis in school. Types of programs viewed in classrooms include ECTV reported by 10 children, science programs reported by 7, standard television programs (e.g., game shows) reported by 5, and art, music, language arts, and foreign language programs were reported by a few of these children.

Hopefully the data gathered from the interview on the television viewing habits of minority children will give new information and insight in this area to Project ONE. The results should show differences and similarities that exist between minority children and other children in their viewing habits. Also, the data should point out variations within the target population in habits along the lines of sex, age, and region. We hope to conduct further research on those aspects of television viewing that require additional investigation.

APPENDIX I

RESEARCH AND EVALUATION MEETING: PARTICIPANTS
July 26 and 27, 1973

Mary Carol Day	Harvard University
Eleanor Duckworth	Atlantic Institute of Education
Charles Gallistel	University of California
Rochele Gelman	University of California
Herbert Ginsberg	Cornell University
Ezra Heitowit	Cornell University
Dalton Jones	University of Massachusetts
Sara Lightfoct	Harvard University

APPENDIX J

FALL MEETINGS

During the fall of 1973, a series of follow-up meetings came after the summer study in exploring nearly every aspect of Project ONE. Many of the fall meetings involved outside participants, including experts in hands-on materials, practicing teachers, school system administrators, eductional researchers, and others.

Two of the meetings, of particular interest in light of the Project's target population and diverse goals, are part of a series dealing with the project's "cultural basis" -- the framing of mathematical objectives in cultural contexts that children in the target population will find appealing, and will speak directly to their own backgrounds, needs and concerns.

In order to confront these important and sensitive issues, and to solicit input and opinions from a wide spectrum of sources, Project ONE has instituted a "Cultural Basis Committee", charged with the responsibility of (1) drawing up a set of cultural issues and concerns in close consultation with the rest of the staff; (2) providing a forum for discussion of these; and (3) serving as a filtering mechanism for translating outcomes of these discussions into recommendations or guidelines for production personnel, again in close consultation with the entire staff.

This Appendix describes the first two seminars held under the auspices of the Cultural Basis Committee.

CULTURAL BASIS SEMINAR NOTES

INTRODUCTION

The Cultural Basis Committee was established to coordinate Project ONE's development of cultural approaches, especially in the planning and production of television materials to reach the target population with maximum impact. The Committee is composed of Project ONE staff members working in production, research/writing, administration, and mathematical content. In general the Committee's task is to provide a forum for raising questions concerning cultural content of the television shows, and a mechanism to disseminate information on these questions. The result has been a series of seminars and "video meetings", most accompanied by written and visual materials, in which guest speakers can share their experiences in various fields. These are open discussion sessions for speakers and staff to explore questions they have had to deal with in the past, in comparable situations, and to make plans for the future.

The seminars attempt to raise questions which the staff will have to consider in terms of our own needs. These questions encompass a wide area, and are held together by our desire to involve in our materials a cultural perspective, an understanding of children's strengths, and an appreciation of mathematics and problem solving already present in the children and their lives.

There are a variety of possible approaches; we are

looking at some of these as others have experienced them, and assessing their usefulness in the work we are doing now.

The speakers are given written materials about Project ONE, about the purposes of the Cultural Basis Seminars, and a list of questions that we think they might wish to consider. Out of this we and the speaker decide on a topic and an appropriate format for discussion, and provide materials to the staff to orient them to the speakers' experience and general approach.

The Seminar is taped and transcribed, and from these materials a concise statement of the seminar is prepared for the staff. The notes from seminars reflect the questions raised both by the speaker in his or her presentation and by the staff during discussion afterwards. These questions then can become the basis for discussion in later meetings -- particularly in terms of what the staff feels we should do in regard to these questions.

One of our primary aims is to provide information to production personnel about possible cultural approaches to video materials. These issues and staff responses to them will gradually emerge in the form of a Production Notebook outlining our best thinking on a variety of topics. The Seminar notes and transcripts will be a part of the Notebook.

The Seminars will try to draw a wide variety of guest speakers. Those in academia, and especially in the arts have much to share with us, and we with them, since these relate to topics we have identified as potentially rich in materials for children.

As the project develops, we hope to include research on childrens' attitudes and preferences into our thinking on guests who could add insight to our efforts. At present, we are still creating mechanisms to raise and deal with questions and to identify people who could help us with them.

We are finding the seminar forum a helpful one, as the notes will indicate, and feel that in time the forum will lend itself to involvement with a diverse group of people, both local and national.

December 15, 1973

Principals: Clifford Johnson and Sloan Williams

The seminar/workshop opened with a three part activity centered around a poem by Langston Hughes. Participants formed small groups and were asked to prepare a play, do a dramatic reading, and present an interpretation of the poem. After twenty minutes, the groups presented their efforts to each other.

The interpretations -- not only of the poem but of the exercise -- raised the issue of the widely varied responses of culturally different individuals attempting to deal with a single stimulus. The stimulus itself triggered many experiential levels: reading, rhythm, dramatic talent, and personal intuitions of connections between the stimulus and the larger environment.

The variety of responses on the parts of groups and individuals demonstrated a tendency to draw upon personal understanding and experience, and to move from within to creative

treatments of the themes.

Sloan Williams gave several dramatic readings of the Langston Hughes poem, employing interpretive styles based on the role of rhythm in the poem's origin. The participants questioned each other and themselves about their personal responses, and the discussion of these interpretations included ideas of language, aesthetic judgment, experience, and cultural roots.

The seminar moved from within this experience framework throughout the rest of the day, conscious of the difficulty of settling or agreeing on one interpretation of an idea, but aware that the experience was more important than the vehicle even though the vehicle might have originated in a culture less familiar to some. The participants discussed the importance of what each individual brings to an experience as the key to learning from the experience. One result was the development in some members of a group identity, evident in repeated references by individuals -- ". . .in our group . . ."

Williams continued, "The role of humanities is to develop and sensitize individuals to their sources, the movement of these sources over time and the variety of sources in different people." A serious question emerged: whether teachers of humanities (and other disciplines) understand the nature of what they teach; that is, that humanities has the experience of people as its roots. The danger of teachers who don't understand the lives of their students is compounded by a growing realization that some don't understand the core of their supposed

disciplines either. Williams drew an analogy between the history of the development of I.S.E.'s humanities curriculum with Project ONE's efforts in mathematics. Students, in asking where ethnic individuals and experiences fit into traditional academic curricula, really want vehicles to make connections between themselves and the larger world around them.

The question becomes: What are the skills to live, and how does a person learn to use these powerful analytical skills to overcome the real obstacles in his path? How does an academic institution or academic force enable students to take possession of personal identity without loosing contact with the roots of life?

The key in the humanities curriculum was a movement back to sources, a continued effort to reach students where they come from and where they are, and an exploration and openness to the meaning and use of information for the present, and especially for the future. This information exchange takes place on many levels. Williams stressed the need for development of bonds of shared experience and open communication as critical in a learning experience.

Clifford Johnson continued: "If you are going to communicate, educate an ethnic group, you have to move from an understanding of culture, that is, the pulse of ethnic life. The natural roots of culture, the reason beneath academia -- this transference of cultural values and symbols -- are present in ethnic prople. The mathematics, science, language, rhythms, arts are all there, in subtle and often elaborate forms. The

sensitivity to see these gifts and to draw upon them is something we all must develop more fully and more personally. We do this the way a musician plays music, not only by woodshedding, or playing and practicing, but by getting onstage with people who may know more about the music and being humble in their presence, drawing upon the life within the self, and creating with that life."

The first step is to make contact with the student, to put the student in touch with the connections between himself and the larger world around him. The academic phrases tend to make students feel more isolated. At the root of those phrases and concepts are ideas and feelings that students experience, and if the barrier of "what the book says" is removed, then the student can make contact with the root, and will have the incentive to figure out additional information.

"Move from academic interpretations to an immersion of people in the experience. Write, paint, weave, take the shift off the academic, put the emphasis into the emotional, tactile. Art and craft is when things are done as an end unto themselves; immersion in an experience is a vital way of making connection with the kids. The emphasis is shifted from a body of materials that must be learned, towards exposing the person to what is inside of self, to the direction or lack of direction -- whatever is there. You don't leave it there, that's exposure; where you go from there is education. How do you help them to use these experiences later on -- ten years later -- to get them to project forward?"

One way is to harness media -- in this instance, television -- and through exploration of the cultural roots of minority peoples to establish understanding of the strengths in the widely varied life styles. These strengths or gifts are some of the sources of motivation. The function of learning is to help people move as whole organisms toward an understandable future. Learning, especially in mathematics, provides tools for understanding the future.

One of the key points of the seminar was a discussion on sources and roots -- directions of human energy. Through an analogy between the musician and his life and our own, we realized that day to day experiences are the source of our creativity and expression. Strength and human security come from a bond developed between people. Material security, accumulation, is a fragile tool in a larger sense; not only does it lead to divisiveness, but it can't create the human strength necessary for life in the cultural sense.

The seminar ended with the understanding that Johnson and Williams would return to continue exploring the ideas of how to use media to reach kids, and some of the cultural issues involved.

December 21, 1973

Principal: Dalton Jones

Dalton Jones opened his seminar by requesting that we give children the same respect that we give animals under scrutiny

in biology, that we credit them with some understanding of the environment in which they live.

The question of his ten years of research: What is the task of childhood? Is it survival, or -- as a child sees it -- a group of social situations within which he/she must function and through which he/she gains the resources (physical, emotional and affective) in his environment?

He then presented a series of categories which he has found useful in analyzing kids' behavior:

1) Obtaining information -- diverse strategies. Kids often get information by giving information, then waiting for feedback. Their requests don't always come in the form of questions.

2) Obtaining behavior or service from other people. Kids often don't know how to do what they need, so they elicit service from adults or others.

3) Eliciting behavior change, deflecting people's behavior.

4) Getting attention, putting oneself into relief.

These are not seen as independent categories, as they overlap quite a bit; but that is true in animal behavior as well as in behavior of children.

Jones: Let us look at the environment in some portions of the black experience. What we were left with after slavery was: One another. We had very few resources, so we developed a set of social domains to a very fine degree. The whole world is within the environment. The whole process of

gaining achievement and competency in that world is what I think we need to spend some time deliberating, because there may be some differences and special points that we need to be very aware of if we are going to gain access to that population. If we are going to open our channels to that world, we need to establish some communication between it and another dimension, which at times has been missing.

The role model issue reflects the things that are in our heads, not in the heads of the kids. If anything comes close to a role model, it is the next peer group up, the age group doing a set of activities which you are not yet old enough to do. The style exists in the community, not in the individuals. You gain recognition by innovating. So I have problems with the traditional role model image as it is conceived and considered in traditional psychology.

Black society is made up of complex images. It is complex to a six year old, who is trying to figure out what's happening. It is a growth process because the environment is constantly changing. You can't focus on an individual -- you have to focus in on patterns across individuals.

I'll show you some situations that continually surprised me because I didn't think the kids would be interested at all. They weren't what we would call appropriate images from black culture, and the kids paid attention anyway. What we have to generate is an interest in a sense of history, in which we are included, of course. What we have to get is a population that is tuned into history or processes, and you don't

get all of the way there by simply putting in black images. There is a process that those images don't carry automatically.

In the research using vidoetapes of kids interacting with each other and with adults, we are asking about the configurations of a cluster of environmental competencies that an individual in a technological society needs to know. By definition, of course, an educational process should lead to environmental competence.

When I start a lecture I usually ask my students to take a moment to thank the individuals who are responsible for our being here, interacting on stolen land -- to thank the Seneca Indians of the Iroquois Federation, as it were. When people try to figure out what is going on, you lead the questions round to eliciting factual information about government, decision making, services. You find that there is a context for beginning to use information, for finding out information, and there are certain experiential grounds and age levels that are aware of these questions.

Information comes not only from specific needs, but is picked up in the environment -- ambient information. If things get picked up as part of a game that kids play together, one of the things that we find in looking at the same kids in kindergarten and second grade is that the rate of behavior, the diversity of behavior, drops by fifty per cent. What the children emit as behavior drops in half between those two environments. The conditions which elicit the behaviors change a great deal.

We ordinarily plug ourselves into situations that don't require changes of behavior; we develop a routine, a set of formats, a set of rituals; we plug into them and they become stereotypes.

Let us refocus. I have, over the last year and a half, been looking very intensely at the behavior of about 28 black kids, half of whom are doing very well in school -- got shining I.Q.'s, while the other half are bottom outers. Trying to look at what is going on in their behavior, doing cognitive analysis and all of that, you don't find very much qualitative difference between the two groups of kids, except in the social domain -- social motivations, and what they are trying to get out of the social situation, including kinds of ways they organize their behaviors and orient (or don't orient) towards adults. The degree to which they are combative with other kids is an attempt, I think, to establish themselves as an authority for the other kids to contend with.

In summation, we can't afford to make assumptions about the motivation behind behaviors. We can look closely, tap the clues that we are able to read, and try to replicate the information that kids are offering us in their lifestyles.